FUNGI AND THEIR ASSOCIATED TREES

From late summer onwards, fungal fruiting bodies of many shapes and sizes can be seen in our woodlands, apparently sprouting up overnight. Many of these mushrooms are a seasonal sign of a symbiotic relationship between certain fungi and trees that continues underground all through the year.

Below: A group of fly agarics surrounding a birch tree—their favourite habitat. The red caps flecked with white (the remains of the volva which once enclosed the whole fruiting body) make this fungus one of the most easily recognised species. Fly agarics are highly poisonous and should never be eaten—nor, indeed, should any wild fungus unless you are absolutely sure that you have identified it correctly and you know it is edible.

In their non-reproductive state, fungi exist as fine thread-like cells called hyphae. Every so often these hyphae throw up spore-bearing organs—the familiar mushrooms, also known as fruiting bodies or sporocarps. Most of the time, however, the fungus exists only as hyphae buried within a food source for, unlike green plants, fungi cannot photosynthesise and have to obtain their food ready-made from other sources. Many feed on decaying organic matter, some are parasitic, while others exist in partnership with living hosts.

A large number of fungi found on forest floors fall into the last of these groups: they obtain their food from living trees. The hyphae of these fungi grow through the soil and colonize the short, fine roots of nearby trees. The fungus covers each root with a sheath of tissue and the hyphae penetrate between the root cells. This association between fungus and tree is called a mycorrhiza and the fungus is said to be a mycorrhizal fungus.

Both the tree and the fungus benefit from this close relationship. The fungus is able to absorb nourishment, in the form of sugars, from the tree. The tree, on the other hand, has its root-hair formation suppressed by the fungus and relies on the latter to absorb water and essential minerals from the soil. As the fungus grows out into the surrounding soil, it becomes capable of collecting water and minerals from a much greater volume of soil than the tree ever could on its own.

Mycorrhizal relationships are formed with many woody plant families, including the beech, birch, lime and pine families. Among the fungi that form mycorrhizas, many are non-specific, that is they can be found in association with several different species of tree, while others are confined to a particular genus of trees.

Amanitas and milk-caps Among the most widely distributed of fungal groups is the genus *Amanita*. These usually have white gills and spores, with a central stalk whose base is typically enclosed within a sac called the volva. This volva once enveloped the sporocarp when it was very small and still

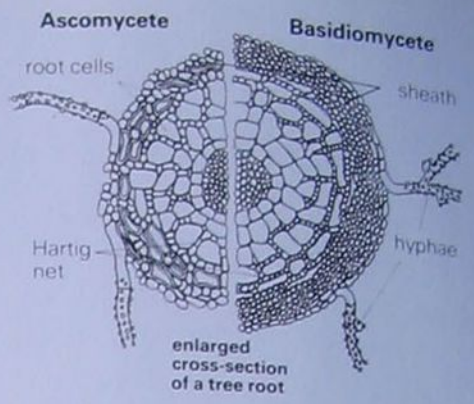
developing.

Two commonly seen fungi in this genus are the blusher (*Amanita rubescens*) and fly agaric (*A. muscaria*). The former is found in many types of woodland. The fruiting body is rosy-brown and the cap is covered in grey warts, the remnants of the volva. Fly agaric is the archetypal toadstool; it appears in large numbers in broad-leaved woods, especially birch.

Another fungus commonly found in birch woods is the ugly milk-cap (*Lactarius turpis*). The milk-caps are so-called because they ooze a white, latex-like liquid if broken. The ugly milk-cap is a dark olive-brown colour. A more attractive member of this genus is the peppery milk-cap (*Lactarius piperatus*). This is one of the most frequently encountered fungi in broad-leaved woods. Its cap, which may reach a diameter of 15cm (6in), is milky white and the gills are also white or yellowish. The white stalk is squat and cylindrical.

Forming a mycorrhiza

To form a mycorrhiza, the fungus envelops the tree root in a sheath and sends thread-like hyphae to form a 'Hartig net' in between the root cells so that nutrients can be exchanged. The mycorrhiza on the right is formed by a Basidiomycete, a large group to which most familiar fungi belong; on the left is one formed by an Ascomycete.



Below: The larch bolete is very common in autumn under larches, its yellow to rust-coloured cap being covered with a distinctive pale lemon slime.

Mycorrhizal associations

The liquid that oozes out when the flesh or gills are damaged is white and has a strongly peppery taste.

Boletes and russulas Birch woods are the home for the brown birch bolete (*Leccinum scabrum*). The boletes all have a central stalk topped by a fleshy cap whose lower surface consists not of gills but of a vast number of pores and fine tubules through which the spores are released. Many boletes possess a fine network of marks known as a reticulum at the tops of their stalks.

The best-known bolete is the penny bun or cep (*Boletus edulis*). To those who enjoy eating fungi, this species is a delight because it has an exquisite flavour and can be eaten raw or cooked. It has a convex cap which becomes flattened with age, while at the same time the pores change in colour from white to olive. The cap can vary from pale ochre to dark chestnut and the stalk, which may be squat or tapered, is a lighter colour. This fungus can be found in broad-leaved and coniferous woods.

A group of colourful fungi also found in

Below: **Slippery Jack** (*Suillus luteus*). Found only in conifer woods, usually beneath Scots pine. A bolete. Height to 10cm (4in). Common and edible.

Below: **The sickener** (*Russula emetica*). A common species in coniferous woods, with a distinctive red cap and white stalk. Height to 9cm (3½in). Poisonous.

Below: **Bay bolete** (*Boletus badius*). A common coniferous species whose lemon pores turn blue when bruised. Height to 15cm (6in). Edible.

Above: **Summer truffle** (*Tuber aestivum*). A rare fungus found buried close to beech trees on calcareous soils. Up to 7cm (3in) across. Edible.

both broad-leaved and coniferous woods is the russulas. The common yellow russula (*Russula ochroleuca*), whose cap may be yellow, ochre or greenish-yellow, is found in a wide range of different woods, while two other species in this group are confined to beechwoods. These are the beechwood sickener (*R. mairei*), a poisonous fungus whose cap varies from red to white, and the geranium-scented russula (*R. fellea*), which has a straw-coloured cap and smells of geraniums.

Coniferous fungi Most coniferous forests in Britain are commercial plantations which appear to be uniform, monotonous stands of just a few species. However, diversity is often provided by the variety of mycorrhizal fungi found in such forests.

Several of the species mentioned above occur in both broad-leaved and coniferous woods. On the other hand, some are confined solely to coniferous habitats. One such is slippery Jack (*Suillus luteus*), which is particularly associated with Scots pine. It is an edible bolete with a chestnut-coloured cap covered in brown slime. The stalk is a pale straw colour and has a large white to cream ring around it that darkens to sepia.

Another edible bolete found in coniferous woods is the bay bolete (*Boletus badius*). As its common name suggests, the colour of its cap varies from bay (reddish-brown) to dark brick-red. When young, the cap is downy but it soon becomes smooth with age.

A bolete with a specific conifer host is the larch bolete (*Suillus grevillei*), which is found only in association with larch trees. The sickener (*Russula emetica*), however, is invariably seen in almost any coniferous wood during autumn. This scarlet-capped russula is poisonous.

Coniferous milk-caps The milk-caps are another common group in coniferous forests.

The curry-scented milk-cap (*Lactarius camphoratus*) is usually associated with pines, though it also occurs in deciduous woods. When dried, the reddish-brown fruiting body develops a strong scent reminiscent of curry. For this reason it is used in Germany as a food flavouring.

The rufous milk-cap (*Lactarius rufus*), which is found in pine and spruce forests, is a reddish-brown fungus with brittle, pale brown gills. It exudes a white latex which, at first, has a mild taste and then, after about a minute, becomes very hot and acrid. Unlike most mycorrhizal fungi, which appear from late summer to late autumn, this species can be seen as early in the year as June.

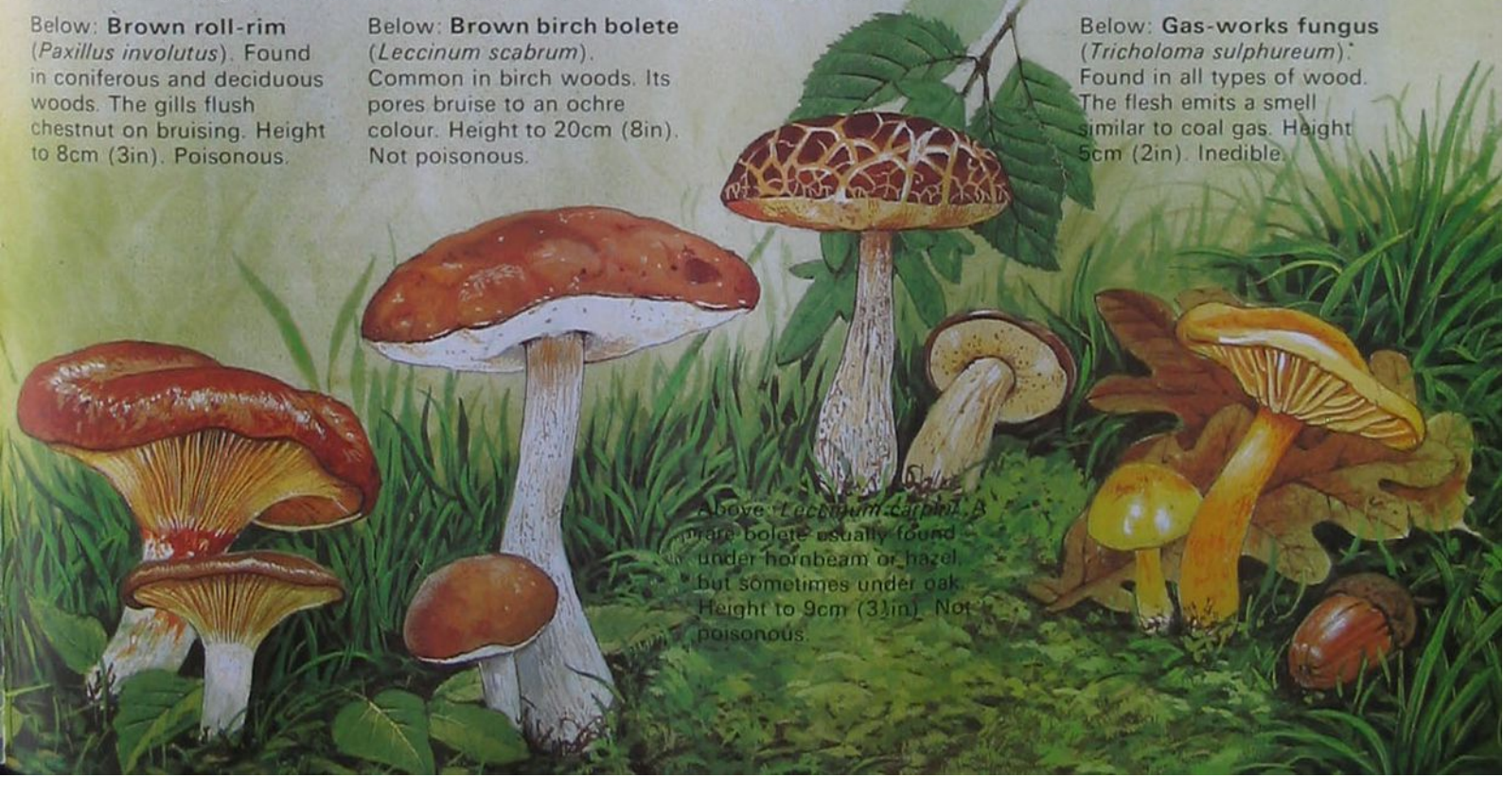
Above: Rufous milk-caps growing on the floor of a coniferous wood. The shape of the cap, with its depressed centre and exposed gills, is typical of many milk-caps. Notice also the white latex being extruded from the gills – hence this group's name.

Below: The fruiting bodies of some mycorrhizal fungi, showing the trees under which they are most likely to be seen growing. All appear mainly from late summer through the autumn.

Below: **Brown roll-rim** (*Paxillus involutus*). Found in coniferous and deciduous woods. The gills flush chestnut on bruising. Height to 8cm (3in). Poisonous.

Below: **Brown birch bolete** (*Leccinum scabrum*). Common in birch woods. Its pores bruise to an ochre colour. Height to 20cm (8in). Not poisonous.

Below: **Gas-works fungus** (*Tricholoma sulphureum*). Found in all types of wood. The flesh emits a smell similar to coal gas. Height 5cm (2in). Inedible.

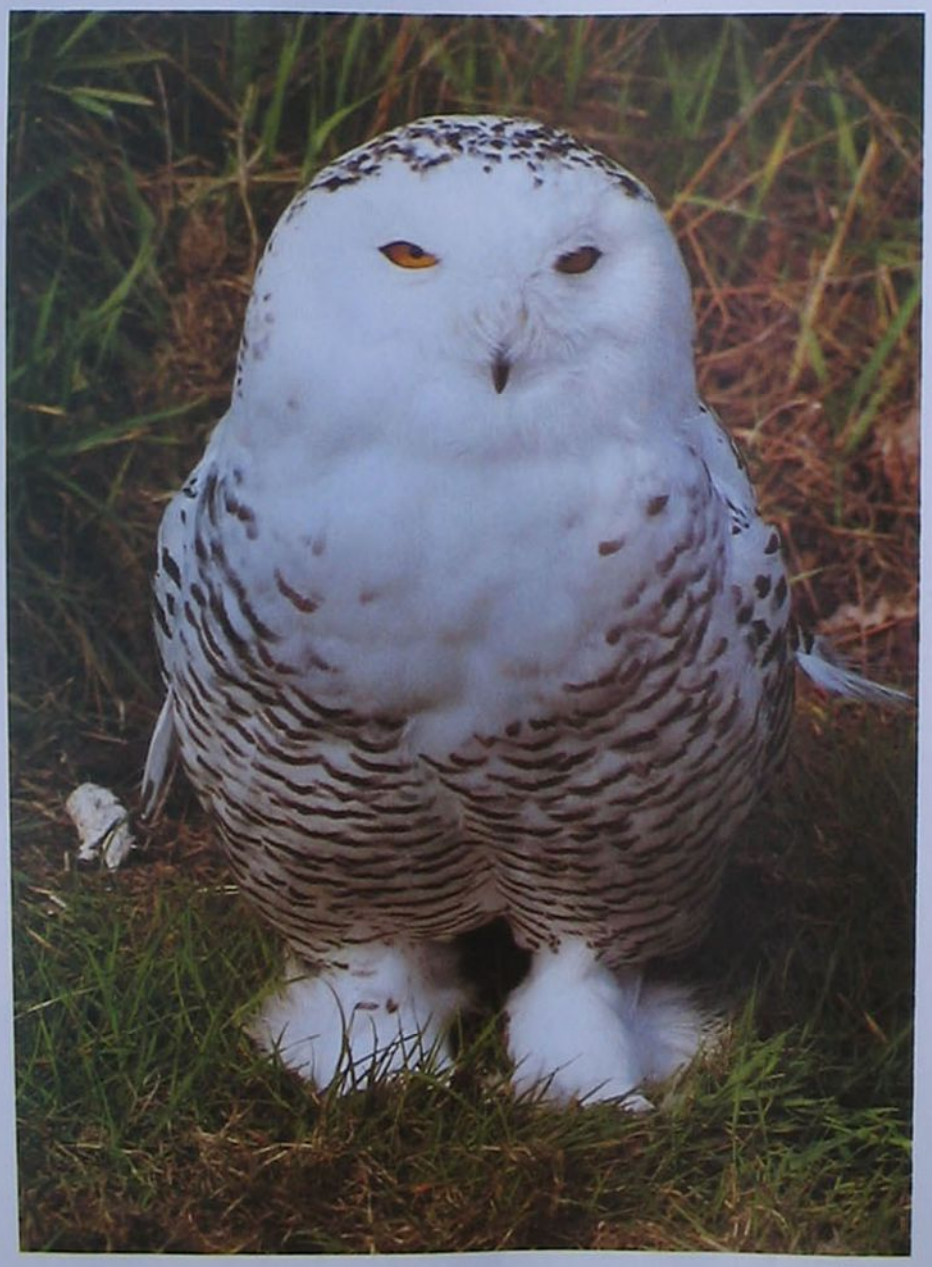


Above: *Leccinum carpini*, a hare bolete usually found under hornbeam or hazel, but sometimes under oak. Height to 9cm (3½in). Not poisonous.

THE SNOWY OWL: A RARE VISITOR

Owls are an almost universally successful group of birds. Few of the world's terrestrial habitats have not been exploited by this adaptable family, and one owl species, the snowy owl, even lives in the Arctic wastes. This species has also bred in Shetland.

Below: A captive female snowy owl poses for the camera. High quality insulation is provided by the dense plumage, the heavily feathered legs and feet, and the long feathers of the facial disc, which partly conceal the strong black bill.



Snowy owls are very rare birds in Britain, although they have long occurred in small numbers during winter, usually as part of the post-breeding season dispersal of some of the population in northern Scandinavia and other Arctic regions. The Shetland Islands, far to the north of mainland Scotland, are the nearest part of Britain to the snowy owl's regular breeding grounds, and it is here that individual vagrant birds, normally males, have been seen with comparative regularity since the early 1960s.

Large, white owl The male is much the whiter of the two adult birds, often with no markings other than a few dark flecks on the wings and back. The female, noticeably larger, with a wingspan of up to 1.5m (5ft), is more heavily barred on the upperparts and slightly less so on the underparts. This barring, which acts as camouflage for the female when incubating on the nest, tends to become less marked as summer advances because of wear and tear. The chicks, thickly insulated with grey down, resemble the adults by the end of their first summer. It barely needs saying that body insulation needs to be of the highest order for a bird which spends so much of its life in a devastatingly cold and hostile climate. This requirement is amply met by the bird's thick and fluffy plumage at all ages.

The Arctic habitat The true home of the snowy owl is on the inhospitable tundra, frozen solid and buried in a blanket of snow for more than half the year. The tundra is a flat, empty expanse of land, but in the brief Arctic summer it is far from being a barren desert, for once the days lengthen and the strengthening sun thaws the snow and ice, this landscape pulses with life. Migrant birds and mammals return to breed in the bounty of plant, insect and aquatic life, and with them come the inevitable predators, which sustain themselves at the expense of others–arctic fox, gyr falcon, skuas, glaucous gull and snowy owl.

Breeding on the tundra Snowy owls have a circumpolar breeding distribution, nesting on the tundras around the coasts of the Arctic Ocean, as well as on most of the archipelagoes. In a few areas, they breed further south, for example in Iceland and the mountainous snow-covered spine of Scandinavia. Wherever they are, however, the breeding grounds of the snowy owl are among the most inaccessible and desolate places in which any birds choose to nest. Observations suggest that these remarkable birds stay in the same range through the icy cold of the Arctic winter as well.

A diet of lemmings In its Arctic and sub-Arctic home in summer, the snowy owl feeds mainly on lemmings, and to a considerable degree the cycles of both brown and collared lemming populations determine the abundance or scarcity of the owls themselves. The number of lemmings normally rises to a peak every four years; at peak times the owls thrive, rearing large broods. After the peak summers, as the supply of lemmings wanes, numbers of snowy owls tend to move south, and in winter these 'emigrants' are seen in areas where the species is not normally encountered. This is the background of all the sightings in Shetland.

If lemmings form the bulk of the diet, how-

ever, they are by no means the only prey of the snowy owl. Willow grouse and arctic hares are taken, and in summer a variety of smaller birds–waders (especially their chicks), snow buntings and occasionally young wildfowl. In winter the main birds taken are ptarmigan and seabirds.

Shetland discovery In the spring of 1967 the RSPB's Shetlands Officer, Bobby Tulloch, observed a female snowy owl several times on the island of Fetlar, and on 7th June he came across a nest with three eggs on the hill of Stakkaberg on the northern slopes of the island. This was the first time on record that the snowy owl had come to nest in Britain. The nest scrape, in a grassy patch on rocky ground, was on the slopes of this windswept hill, where low vegetation all round was reminiscent of the prostrate plant cover typical of the bird's Arctic breeding grounds.

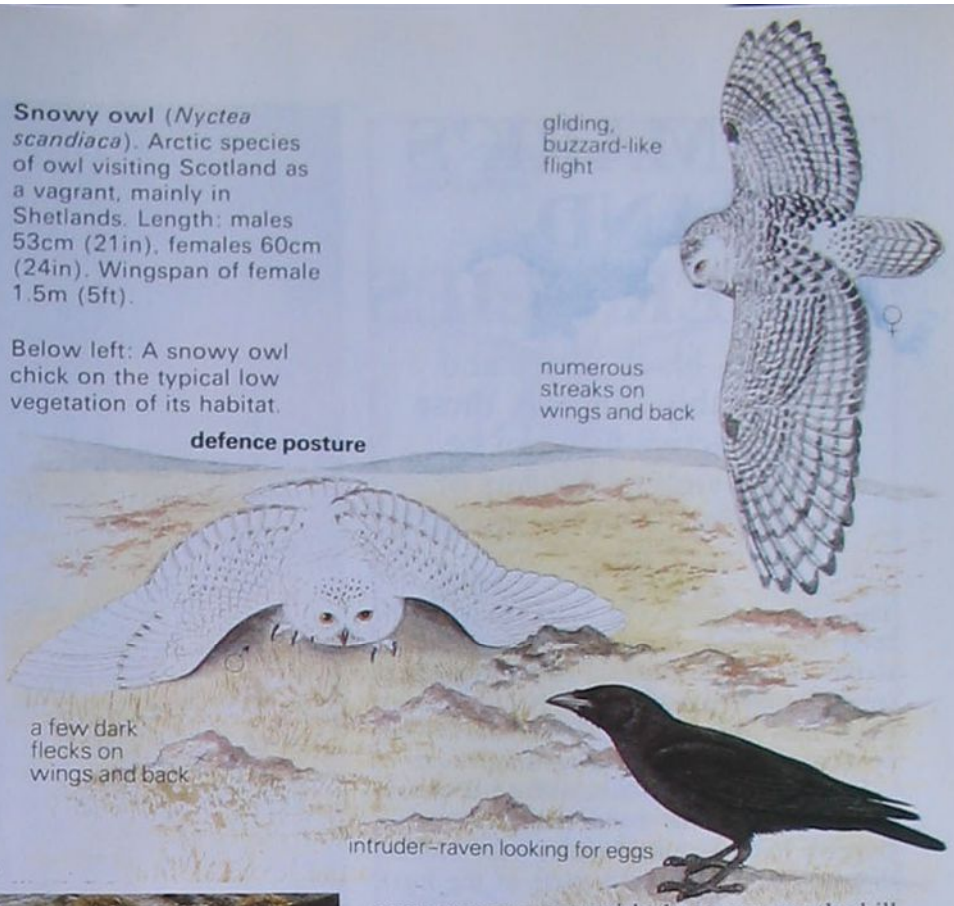
In Shetland, the low hill on Stakkaberg gave a wide view of the surrounding area, giving some warning of any approaching danger. Although lemmings do not occur on the Shetlands, there are rabbits in plenty, and these formed the major part of the food of the birds that lived there, and later their young. Other birds breeding in this part of the island were also taken–arctic skuas, oystercatchers and other waders. In 1967 the Shetland pair produced seven eggs, and eventually in August five young successfully flew.

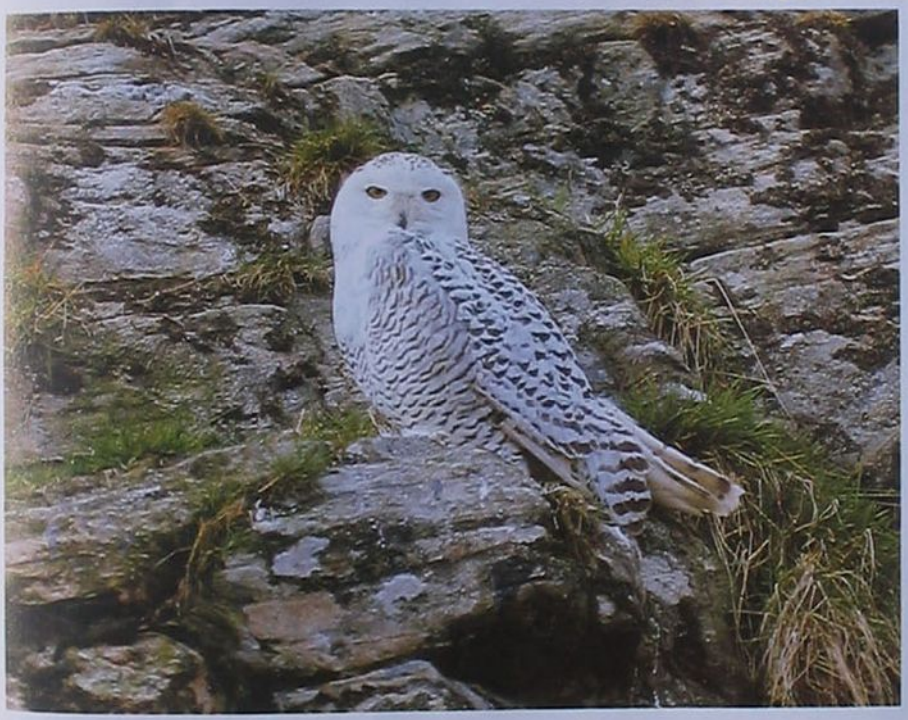
Fetlar is much visited by birdwatchers, and from the outset in 1967 it was clear that the secret could not be kept.

In 1968, to the delight of the many birdwatchers among whom word had gone round about this exciting phenomenon, the original pair of snowy owls were still on Fetlar and reappeared on the breeding site. During the seven years from 1968-75, these two parents raised a further 11 young. In some years a second female was seen to have laid eggs, but these did not result in new families. Eventually, the old male snowy owl disappeared and, having previously driven off all the young males, left the females without a partner. The short, exciting phase of snowy owl breeding in Britain had ended, for since then only a few individual birds have lingered on, and none has paired or bred.

Snowy owl (*Nyctea scandiaca*). Arctic species of owl visiting Scotland as a vagrant, mainly in Shetlands. Length: males 53cm (21in), females 60cm (24in). Wingspan of female 1.5m (5ft).

Below left: A snowy owl chick on the typical low vegetation of its habitat.





Above: A female snowy owl roosting on a limestone outcrop. Her plumage is richly barred with brown, especially on the back and wings. This is good camouflage at breeding time in the Arctic, when the background often consists of broken patches of snow.

Right: The long feathers of the facial disc of a male snowy owl. He lacks the mottled crown of the female. The eyes of both sexes are a liquid golden yellow.

ST MARK'S AND FEVER FLIES

Large, black, hairy and remarkably sluggish, these unattractive flies can be seen flying in swarms or on vegetation in the spring.

The curiously named St Mark's fly and the fever fly are closely related, both belonging to the family Bibionidae of the order Diptera (true, or two-winged, flies). In North America these flies are referred to as March flies because they appear in springtime.

Sluggish swarmers Bibionidae are nearly all black, stout in build and with rather sluggish habits (some females have reddish thoraxes, abdomens and parts of the legs). In both sexes the legs are robust, the forelegs being equipped with unusually heavy spines–a characteristic which makes them particularly easy to identify when you see the flies on vegetation in spring. Their wings are fairly broad but not unduly long, and often smoky with pale hind veins.

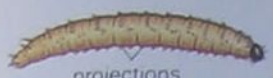
The males of all 18 British species of Bibionidae perform a lazy dancing flight, moving up and down in swarms, not unlike the mating swarms formed by midges and mosquitoes (in the Bibionidae, however, the swarming only takes place in bright sunshine). Their flight suggests the act of dipping down to drink, hence the name *Bibio*, derived from the Latin 'to drink'. The females cluster, sometimes in fairly large numbers, on flowers or foliage near the male swarms, to attract their prospective partners. They mate on leaves or grass, joined end to end.

Burrows for the larvae After mating the female excavates a burrow in the ground, then lays 200 to 300 eggs in a cluster within it. The eggs are up to 7mm long, and white at

Above: The St Mark's fly (*Bibio marci*), so called because it appears around St Mark's day (25th April), is one of the largest and more obvious species at 10-12mm ($\frac{1}{2}$in) long. A heavy looking, hairy black fly, it can be found sitting on vegetation in large numbers. The female has smoky wings and flies sluggishly, while the male (above) has clear wings and flies vertically up and down, with his long hindlegs hanging down. Both sexes have strong, heavy forelegs with swollen tibiae (seen clearly in the picture on the right). These tibiae end in two thick spines which are used by the female for digging her egg chamber, and by the young adults when they emerge from their pupal chambers.

Left: A pair of St Mark's flies mating. Copulation usually takes place on a leaf or a blade of grass, with the male and female joined end to end.

Fly larvae



Above: The **St Mark's fly**, an example of a simple fly, has a larva with a very conspicuous head.

Above: The **fever fly** larva, like the St Mark's fly larva, is simple and has a visible head.

Above: The **blow-fly** larva—one of the highly evolved species—appears to be almost completely headless.

first, although they become darker later.

All dipterous larvae lack legs and the Bibionidae larvae are no exception, wriggling their way through the soil using their spines and projections to give them a grip. Their heads are shiny, dark blackish-brown and quite conspicuous and they have normal chewing mouthparts with mandibles that bite from side to side—all characteristics of simple fly larvae.

These larvae live gregariously, feeding on leaf mould, decaying organic matter or rootlets in the soil. They are themselves a source of food for ground-feeding birds such as pheasants, the stomachs of which can sometimes be found crammed with Bibionidae larvae. The larvae moult three times and then, in the spring, when they are fully grown (the largest larvae are 2-2.4cm/$\frac{7}{8}$in long), they form chambers in the soil where they pupate. The adult flies emerge from the soil about three weeks later.

Different species The St Mark's fly (*Bibio marci*) is the largest of these flies, although another species, *Bibio hortulanus* is nearly as bulky. The males of both species are large, black and hairy, but the females of *B. hortulanus* have reddish bodies with only the head and parts of the thorax black. *B. hortulanus* is seen later in the year (June) than *B. marci*, although it is not as gregarious. Two other smaller black species, *Bibio clavipes* and *Bibio lepidus*, are only 8mm ($\frac{1}{3}$)in long and do not appear until September or October. All species have a short period of flight, disappearing after about a fortnight.

Fever fly or blossom fly The fever fly (*Dilophus febrilis*) was named by the great Swedish naturalist Linnaeus because the country folk in 18th century Sweden believed that the male flies swarmed outside the homes of fever-stricken people. In some parts of Britain it is called the blossom fly.

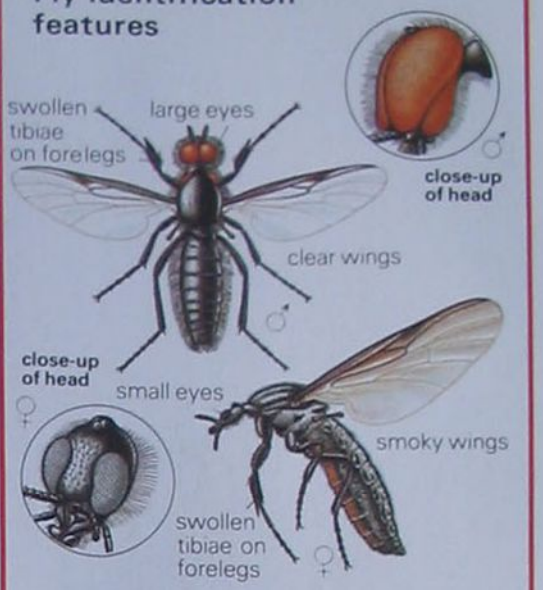
Abundant almost everywhere, especially in grassy places, it appears in early spring and can be found as late as October, indicating more than one brood a year. At 6-7mm long, it is one of the smaller Bibionidae species, and is black with smoky wings, especially in the females in which they are noticeably much paler at the tips.

The fever fly sometimes appears in particularly large numbers, when you can see the females clustering on stems. The males can generally be seen flying in low swarms near the females.

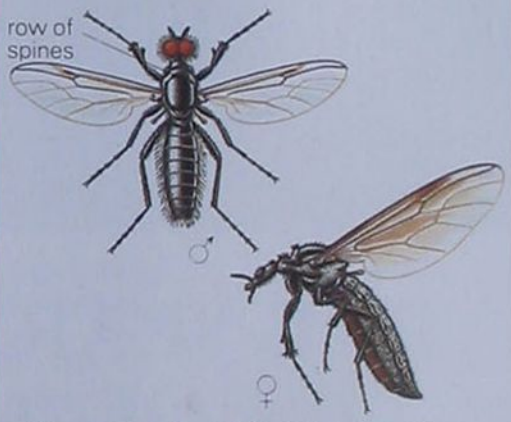
Economic importance The fever fly is of some agricultural significance as the larvae are said to damage the roots of various crops, especially hops—they also feed in grassland where they cause brown patches on lawns, presumably because they have been eating the roots. As they frequently breed in rotted manure and leaf mould, it is possible that they are introduced in the 'top-dressing' applied to lawns.

Conversely, they do have their advantages, being of some importance in the pollination of fruit blossom as they are present in such large numbers in spring.

Fly identification features

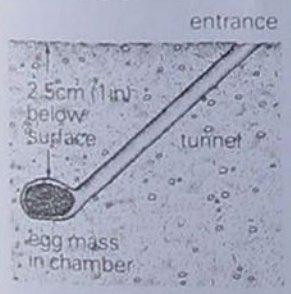


Above: The heads of the male and female **St Mark's fly** differ. While the female has small, widely spaced eyes the male has enormous eyes.



Above: **The fever fly** differs from the St Mark's fly in the structure of its legs—the fever fly has no swollen tibiae—and in having a row of thoracic spines.

The egg cell



The female St Mark's fly digs a burrow in the soil with her forelegs, turning from time to time to press the soil aside. She then makes a cell and lays her eggs (200-300) in a mass before dying near the cell.

ONE YEAR IN THE LIFE OF A VIXEN

A young vixen (above) trotted purposefully across a field towards a village in the Oxfordshire countryside. This agricultural landscape was the setting for a fascinating study of the comings and goings of a young vixen during one year.

The village for which the vixen was making was surrounded by fields of arable crops, dairy farms and market gardens, and it consisted of a cluster of houses and two farms. In January she was approaching nine months of age. She was a typical lowland fox, making the most of all possible sources of food as their availability changed with the season. Now, in winter, she was searching for scraps from around bird tables, and sometimes she went 'mousing' around farm buildings.

She had been born in Oxfordshire the previous spring, and was now the only one of her litter-mates to remain in the area of their birth; the others had either dispersed or had been killed. The area she used regularly, her

Right: The vixen searched hard for a suitable earth and eventually found one which had been disused for several years. It was originally part of a rabbit warren but different occupants had adapted it for their own use.

Opposite page (bottom): In mid-January the young vixen came into oestrus and mated with the dog fox. They remained locked together for 20 minutes before going their separate ways.

home range, was one part of a group territory of approximately 200 hectares (500 acres) which she shared with her mother and a dog fox. All three lived within the same well defined boundaries of the group range, but pursued independent existences, foraging alone and meeting only rarely.

In mid-January the young vixen was coming into oestrus for the first time. As her attractiveness increased over successive nights, the normally well-respected borders of the group territory were ignored by neighbouring dog foxes, and by night these interlopers formed a trail led by the vixen and the resident dog fox. During the three days when she was sexually receptive the dog fox rarely left her at night, and throughout the day they remained together in one of their regularly used daytime refuges. Only after they had mated did they resume their usual solitary lifestyle.

February-March With February came freezing weather and snow. This blanket of snow made it more difficult to find food, and the vixen had to work hard to catch sufficient to eat.

In late February and early March she began to investigate potential den sites in which to give birth, examining old dens and starting several new ones. She eventually selected one which had been disused for a few years. Originally part of a rabbit warren, this was a typical fox earth: two entrances to a series of tunnels dug in sloping ground. Former occupants had enlarged the tunnels and extended the den, and with a little re-excavation it was ready for use.

In mid-March, after eight weeks of gestation, the vixen gave birth to five cubs in a bare nesting chamber inside the den. At birth the cubs were furred but blind, weighing approximately 130 grams (4½oz) each. Their downy dark grey fur, small bent ears and snub noses made them look quite unlike foxes. Only the white-tipped tails of some of the cubs betrayed their identity. Within a few hours of birth they were remarkably active inside the den, uttering small squeaks as they tumbled blindly over each other in their efforts to reach their mother's nipples.

Above: During February the vixen spent two especially cold nights curled up within a farmyard woodpile. Outside she would probably use more energy in keeping warm than she could acquire from the available food. But this policy of remaining inactive could not be pursued for very long. Her limited fat stores meant she would have to hunt almost every night, using virtually all the nocturnal hours to find sufficient food.

Right: One of the five cubs waiting outside the den for the vixen to arrive to suckle her young. From about four weeks old the cubs were also eating solid foods brought back by their parents.

For the first few days after the birth the vixen remained with her cubs continuously. The resident dog fox brought her food, such as rabbits and rodents, but she soon began to leave the cubs for short periods to make brief excursions to forage for herself. Every few hours during the night she would leave the cubs to go to a favoured site to feed but she always returned after less than an hour. During the first few weeks of the cubs' lives, and while they stayed inside the den, these nocturnal trips gradually became more prolonged. Soon the vixen began to spend the day away from the cubs, sleeping nearby in the undergrowth of a hedgerow or in the long grass of a plum orchard.

April In mid-April, at the age of four weeks, the cubs emerged from the den for the first time. They now weighed almost a kilogram (about two pounds) and their grey eyes had opened, but they still retained their coat of downy fur. Over the next six weeks this would change into the chestnut coloured fur of the adult. As the evening light faded, some of the

Above: Food was often buried and retrieved later on a night of scarcity. Like all foxes, the vixen had an excellent memory and would return to the exact spot where she had earlier made a larder.

Below: The growing cubs emerging from their den at night in mid-summer. By now they were accompanying the vixen on her foraging trips and learning her special hunting skills. Soon they would go out alone.

cubs scampered uncertainly around the den entrance while others sat waiting for their mother to arrive. For the next few weeks, while the cubs were still dependent on their mother for milk, she would arrive at nightfall to suckle them before going off to hunt. Already the young foxes were eating solid foods and competing aggressively for prey items brought back by both parents. Unlike some other canids (jackals and African hunting dogs, for example), which regurgitate food to their young, foxes always carry prey back to the den. As a result only comparatively large items such as rabbits are worth taking back to the cubs.

May-June In early May the vixen moved her litter, carrying each cub in turn to the new den at the edge of a wheat field. Around the den entrance the growing crops rapidly became trampled as the cubs played–pouncing on inedible food remains or on each other in mock attack. By the middle of the month the cubs were quite mobile, and although they spent much time around the den they also travelled away from it for distances of several hundred metres. This early exploration marked the demise of one of the litter. She had reached the edge of a stream and tumbled into the fast flowing waters. Swept downstream, she reached the opposite bank and struggled out but, soaking wet, cold and lost, she quickly perished.

The warm early summer weather of June created easier conditions for the vixen. Although the food demands of the cubs were consistently increasing, prey was now much more readily available. At dusk the vixen would travel to some particularly rich pastures in search of earthworms, which had surfaced to mate, and other invertebrates, before taking food to the cubs. Later in the night when human activity was at a minimum she would forage in the village for scraps. The well tended lawns around the houses were another good source of earthworms, but here she had to compete with hedgehogs for these prey. In early winter, when food was less easily obtained, these hedgehogs might themselves become the prey of the fox; but in summer months the plentiful invertebrates were a much easier source of food than the well protected hedgehog.

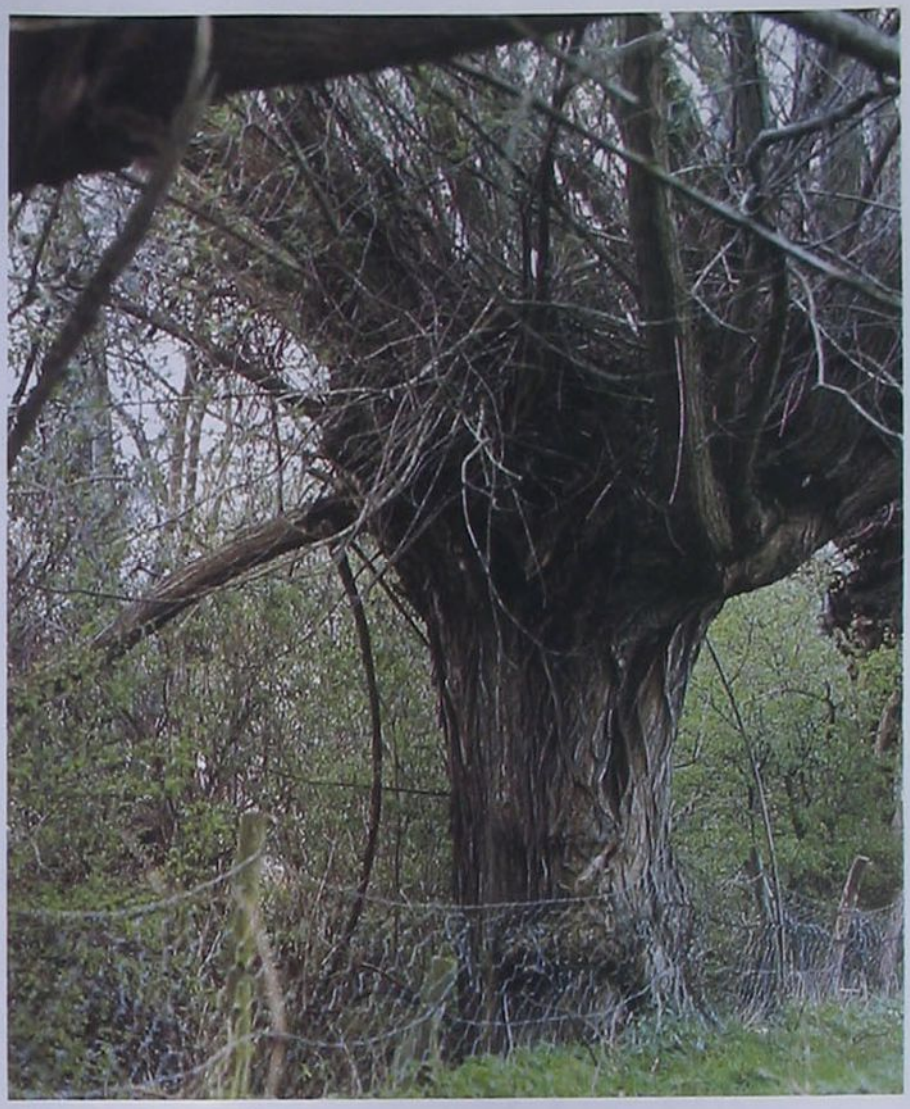
Mice and voles were also an important part of the vixen's food. Walking quickly and quietly to a particular spot in some long grass she would listen intently for the sounds of their movements. Having located her prey, she would leap in a graceful arc to pounce on it with her forepaws. Each capture was chewed minutely before being swallowed, or was buried nearby, to be retrieved later on a night of food scarcity.

Travelling through her home range, the vixen paused frequently to scent mark. She usually sprinkled small quantities of urine on a prominent object such as a rock, tuft of grass or some scrap of uneaten food. Many of these sites were marked repeatedly on successive nights, so continually topping up the 'scent-posts'. Their role was two-fold: to communicate with other group members, and to warn potential intruders that the area was occupied. Indeed, it may well have been the information in these urine marks which caused the breakdown of territory borders when she was in oestrus.

From June onwards the vixen was frequently accompanied on these foraging trips by one or more of her cubs. They took great interest in her activities, attempting to mimic her prey-catching techniques. In this way they acquired the special hunting skills of their parent.

July-August By July the cubs had reached three-quarters of their adult weight (5-7kg/11-15lb) and often foraged alone, sometimes venturing quite far outside the home range. Now that the demands of the cubs were diminishing, the vixen was recovering her condition. She spent large parts of each night in the small market garden area, feasting on the ripe strawberries and plentiful invertebrates.

August marked the death of the adult dog fox. In his customary dash across a main road which lay within his range, he was struck by a car and killed. At just over two years of age, his lifespan was typical of a fox living in close association with man.



Above: During July the vixen often slept by day in the top of a pollarded willow, or in a field of wheat or barley. Both sites gave a good chance of detecting any disturbance, and offered good escape.

Below: Winter, and the fox inspected a hedgehog.

Autumn September brought the fruit season and another change of diet for the vixen. Fallen apples and plums were eaten in quantity, the pips, stones and fragments of skin forming the bulk of her droppings. Blackberries, too, were plentiful.

During this month her young male offspring made regular excursions beyond the borders of the group range. These were usually short trips, the foxes returning before dawn. In October and November these journeys became more prolonged and more extensive, and were a fore-runner to the dispersal of the young.

As winter approached and food availability declined, the pressures on the vixen's offspring increased. Since they were subordinate to the adult group members, they were forced to forage in the poorer areas not being exploited by the adults. In December the sub-adult males (now no longer cubs) left their natal group range permanently. By the end of the year most yearling dog foxes would be dead; killed by accident or as pests, or in the name of sport by their major predator, man.

In the last nights of the year a new dog fox arrived in the vixen's range. His call, a hoarse 'wo-wo-wo', declared his residency, and as the vixen approached her second period of oestrus the year had come full circle.

TELLINS AND RAZOR-SHELLS

After a storm, vast numbers of empty razorshells and tellin shells are found cast up on the beach, revealing the great abundance of these burrowers.

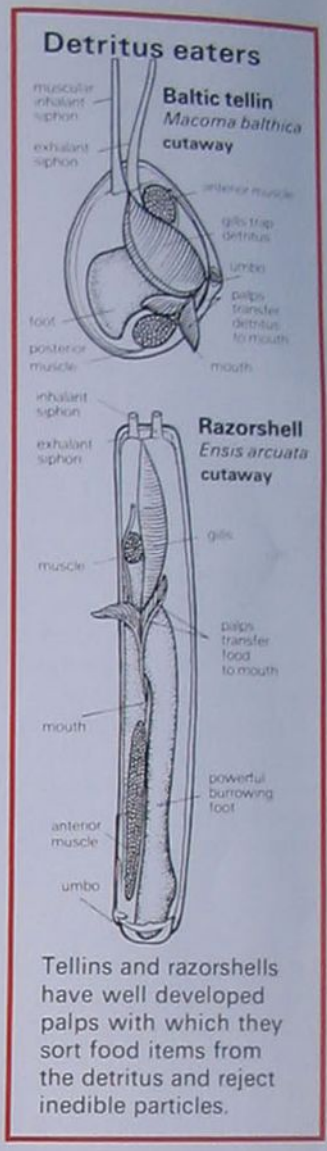
Tellins have thin, smooth shells, compressed to ease passage through the sediment of the sea-bed. The burrowing foot is expanded into a wide blade, which pulls the tellin through the sand. Tellins lie on their left sides when buried, and remain in contact with the seawater above by means of two long, mobile siphons–one carrying an inhalant current, the other an exhalant one.

For food, most bivalves filter small organisms (plankton) drifting in the seawater. Tellins have changed this method slightly, for they feed on items of detritus (decaying organic material) lying on the sediment.

Three common tellins The commonest tellin on British sandy shores is *Tellina tenuis*, a fragile species up to 2.5cm (1in) long, with a translucent white shell, often tinged with pink, orange or yellow. *T. tenuis* lives in fine sand and may be found from the middle of the shore down to several metres below low tide. It burrows as deep as 10cm (4in) but is usually shallower when feeding. It occurs in vast numbers–often exceeding 1000 to the square metre.

Tellina fabula is smaller, usually less than 2cm ($\frac{3}{4}$) long, and is characteristically pointed at the rear. It lives in clean, though often silty sand, usually at lower levels on the shore than *T. tenuis*, but with an overlapping distribution. *T. fabula* is sublittoral, being most common at depths between 5 and 15 metres (2-8 fathoms).

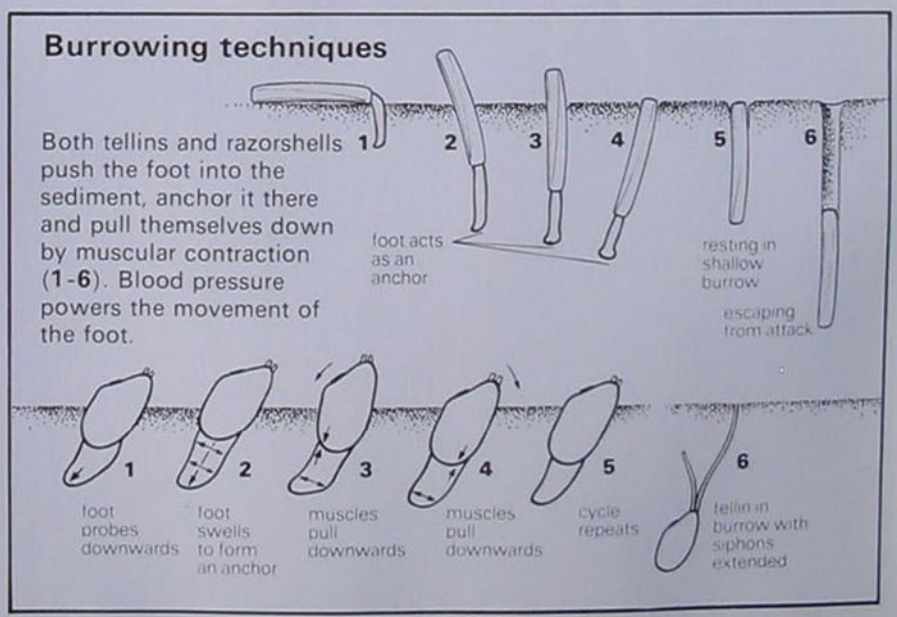
On sheltered shores where sand is replaced by mud rich in organic detritus, *Tellina* is replaced by *Macoma balthica*. This is a larger,



Tellins and razorshells have well developed palps with which they sort food items from the detritus and reject inedible particles.

Above left: *Ensis siliqua* washed up on a stony beach –where it cannot have been living–in southern Ireland.

Right: Three specimens of *Tellina*, with their siphons extended.



heavier tellin, and large specimens often exceed 2.5cm (1in) in length. The shell is smooth and of variable shades including white, yellow, pink and purple, perhaps in concentric bands.

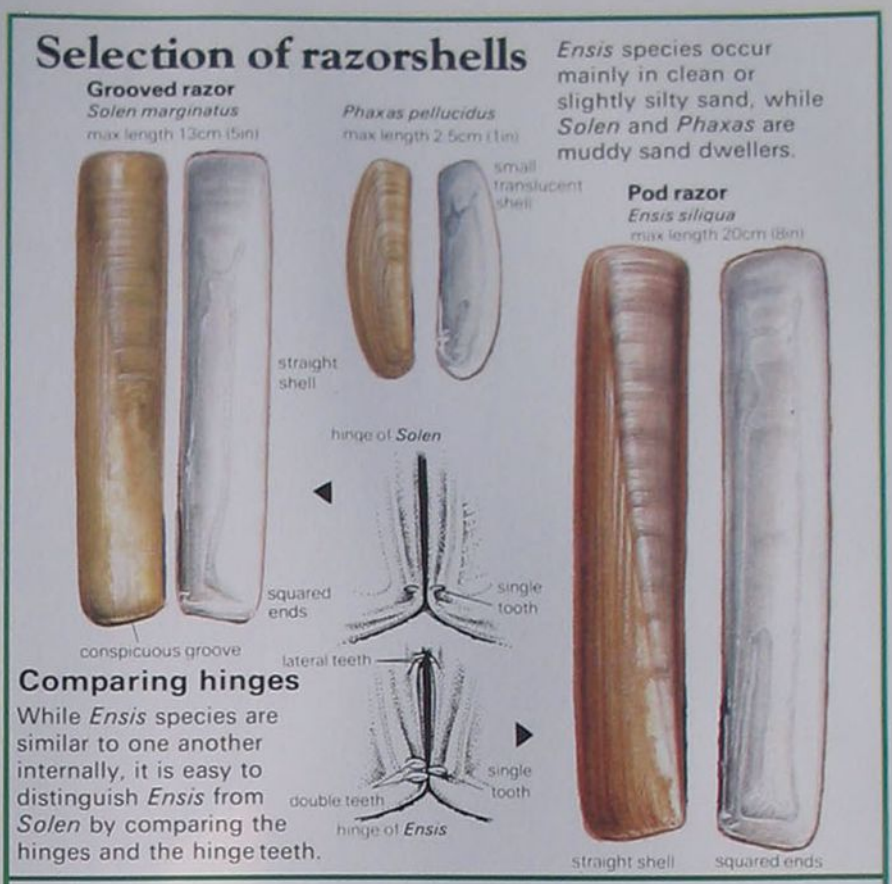
Cut-throat razors Razorshells are so called because they resemble old fashioned cut-throat razors. They are widely distributed in the sand on the lower shores of our coasts, their burrows being uncovered by low spring tides.

Razorshells are very rapid, deep burrowers; being sensitive to vibrations, they often disappear well beyond the depth to which would-be collectors usually dig. A characteristic key-hole depression is left in the sand by a burrowing razorshell, and the simple trick of tipping salt down the burrow irritates the beleaguered victim, causing it to appear without resort to digging.

Razorshells have developed considerably from the typical bivalve shape. The almost rectangular shell has increase in length by elongating towards the rear–so that the umbo (a small protuberance), and the hinge and ligament (originally placed centrally) are now located at the extreme front end. The foot is enlarged to occupy two-thirds of the shell before emerging at the front (bottom) end. At

the back (upper) end, the short siphons protrude. These siphons do not need to be long (as in the tellins), for the whole razorshell can move up and down in its vertical burrow, relying on rapid descent for survival in the face of predatory attack, such as by wading birds. The smooth shell offers little frictional drag in the burrow.

The most widespread group of razorshells in British waters belongs to the genus *Ensis*. The three species of *Ensis* live buried in sand, and are of similar colouring: white with red-brown streaks and blotches. *Ensis siliqua* is the largest, reaching a length of 20cm (8in) and a width of 2.5cm (1in). The long sides of the shell valves are almost parallel, so that the razorshell appears rectangular, whereas the other two species (*E. ensis* and *E. arcuatus*) are slightly curved. It lives in fine sand, its range extending to 35m (18 fathoms) in depth.



TEMPORARY POOLS: A CHANGING REGIME

Many slight depressions in the ground hold rainwater all through the short, cold days of winter and lie empty in the warmer months, when evaporation exceeds precipitation. The wildlife in these temporary pools has, therefore, to be highly adaptable.

Right: This species of caddisfly—*Glyphotaelius pellucidus*—is often abundant in temporary pools.

The advantage of inhabiting a temporary pool lies in the relative freedom from predation. No fish of the European fauna can withstand the disappearance of water. Some carnivores, mainly beetles, regularly invade temporary pools and sometimes breed in them, but when they do so their active life must start with that of their prey. The result is that species which might provide a copious supply of food in a permanent pond are too large to attack.

Mosquito life-cycles The fauna of temporary pools is surprisingly diverse, but interest has centred on those animals whose way of life confines them to such places. Larvae of the mosquito genus *Aedes*, whose adults attack man fiercely, abound in the smaller pools. The larvae of *Aedes cantans* occur in pools in woodland, often with *A. rusticus* which, however, also inhabits water that is not densely shaded. *A. cinereus*, another species, is associated with fens and low-lying meadows.

The female mosquito in this genus lays her eggs on damp ground and has been observed to crawl beneath dead leaves to do so. The eggs perish if they become too dry, but survive for a long time in the damp atmosphere generally found at the surface of the soil. The embryo develops within the damp egg and may be ready to hatch within a few minutes of immersion, but conditions governing embryonic development vary greatly with the species. The development of some is retarded unless the egg is exposed to temperatures near freezing, while high temperatures may be a necessary stimulus to hatching. Immersion is obviously the primary stimulus but the lower concentration of oxygen in water and other chemical factors may be involved as well. The larvae of *A. rusticus* may appear in the autumn and reach the final stage of larval development by Christmas, but pupae are rarely found before March. In contrast, larvae of *A. cantans*, perhaps in the same pool, are not to be found before January. The hatching of *A. cinereus* occurs later still.

Above: Fairy shrimps—crustaceans of a primitive type and an inch or more in length—can sometimes be seen in the larger temporary pools.

Opposite page: A temporary pool in a Surrey woodland. In our relatively warm climate, with no clear-cut rainy season, there is great variation from year to year in the water regime of such a pool. Nevertheless, some species of animals have adapted to this habitat. For instance, adult bugs and beetles may fly in and leave again before the pond dries up, while other insects breed in the temporary pool and then repair to more permanent water for the next generation.

Left: *Triops cancriformis*, an extremely rare crustacean, may occasionally be found in temporary pools.

Some species undoubtedly achieve only one generation a year, but for others it is not easy to be certain. The females, nourished by blood (often of human origin), live for weeks or even months and mature a batch of eggs after each meal. If the eggs are laid near the edge of the shrinking pool, larvae will appear at intervals as the water level subsequently rises, and so all stages may occur together.

In the British climate a pool can be filled by heavy rain at any time of year, but the water

Above: An algae-choked temporary pool adjacent to arable farmland in Cheshire. Temporary pools in the vicinity of farmland are not all that common. It is evident that many aquatic organisms which have no winged stage can survive for a time in the damp conditions at the bottom of a waterless pool. Pulmonate, or air-breathing, snails, such as the commonly seen ram's-horn snail (opposite), often do this. Three species are found regularly in temporary water, one of them being *Lymnaea truncatula*, the alternative host of the liver fluke which, a serious menace to sheep, sometimes infests man. Farmers therefore usually fill or drain such possible breeding places which, together with the lower rate of evaporation, is why temporary pools are seen most often in woodland.

may be gone before a generation of mosquitoes is completed. Some species guard against this possible total loss by producing eggs that require different strengths of stimulus to induce hatching. Some respond to a weak stimulus by hatching when first submerged, but others do not hatch at the first contact with water and survive to populate the pool later if earlier inundations did not last long enough.

Mosquito larvae breathe air, which they take in through two spiracles at the end of a tube, and are independent of dissolved oxygen–a substance often in short supply in a pool floored with decomposing leaves. Brushes on the front of the head keep a current of water flowing over the larvae's mouthparts, the larvae feeding on micro-organisms in the water. They also descend to the bottom and scrape the surface of the dead leaves.

Unusual inhabitants In temporary pools somewhat larger than those in which mosquito larvae abound, the fairy shrimp (*Chirocephalus diaphanus*) may occasionally be seen. It is a beautiful creature and one of the most spectacular of freshwater organisms for, unlike most, it does not lie concealed in cover but swims perpetually. It must keep swimming for the rhythmical beating of its limbs not only propels it but drives a current of water forwards between the bases of the limbs to the mouthparts. There small food organisms are filtered, manipulated and swallowed. Clearly an animal with this way of life can survive only in places never permanent enough to harbour fish. Some of the fairy shrimp's eggs hatch without exposure to air, but most lie on the bottom until the pool has dried and refilled.

Another crustacean of primitive type, though not closely related to the fairy shrimp, is *Triops cancriformis*. Its characteristic fea-

ture is the broad shield-shaped carapace covering the forepart of the body. It is extremely rare in Britain, possibly because the temperature rarely reaches its optimum. The late Professor H Munro Fox wrote that there were but five published records between 1738 and 1943, though manuscript records suggest that it may have been a little more numerous early in the last century. No finding since 1943 is known to the writer, but today the informed naturalist who encounters such a rare and unusual creature does not publicise the event. Fox obtained specimens by placing in water dry mud from the pool where the creature had last been reported. *Triops*, unlike the fairy shrimp, swims right way up but resembles its relative in the possession of a series of limbs in constant rippling movement. The animals feed, however, by dabbling in the mud in search of worms, chironomid larvae and other small organisms.

One more unusual animal, *Mochlonyx culicidiformis*, is found only in temporary pools. It is related to the mosquitoes and structurally the larva is intermediate between *Aedes* and the phantom larva *Chaoborus*. The respiratory system terminates in a structure like that of a mosquito, but also comprises hydrostatic air sacs, which enable the larva to hang motionless in mid water. The other feature besides air sacs in which *Mochlonyx* resembles the phantom larva is in the antennae, which are modified for seizing prey. According to a Danish author, it feeds mainly on small crustaceans but takes mosquito larvae as well. Its life history is similar to that of *Aedes* and the larvae are found in March and April. This short, early larval life may partly explain why records of the animal are so few.

Small crustaceans are numerous in the open water of lakes and large ponds, where their only protection against predators–fishes and a variety of arthropods–is their diminutive size, coupled with an ability to reproduce very rapidly when conditions are fair and to lie dormant on the bottom in a resting stage when they are not. Tactics like these are also appropriate for life in temporary pools, and these organisms flourish in such places.

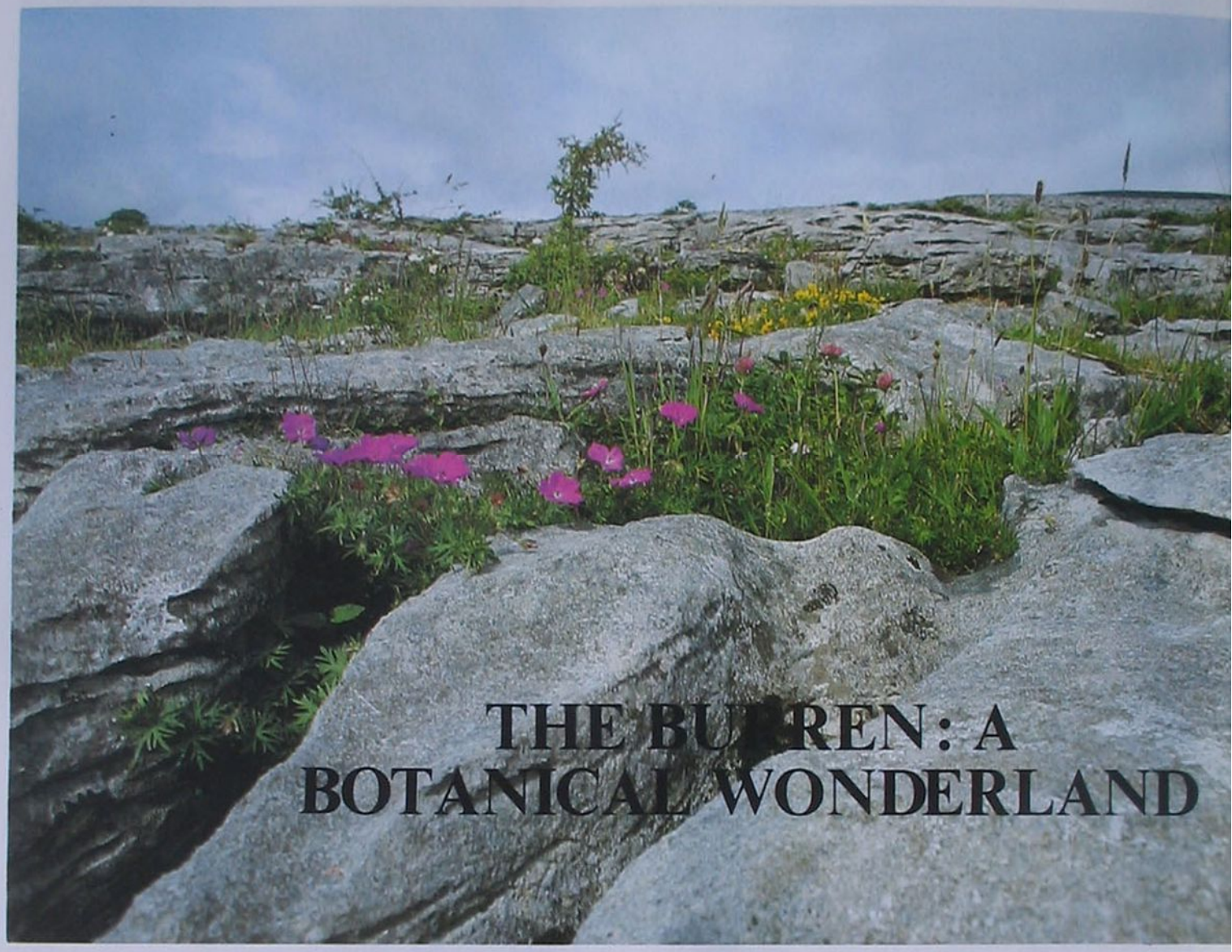
Carnivorous life in temporary pools Beetles are the main carnivores in temporary pools. Many of the adult individuals have probably dropped in during the course of casual wandering, but larvae also occur. As their development is rapid (provided, of course, that the food supply is good), and as they leave the water to pupate, a generation can be completed if the eggs are laid early enough. Some adult beetles have been found in the dead leaves and other vegetation at the bottom of a dry pond, and one species –*Agabus chalconatus*–inserts its eggs into the peat at the bottom of moorland ponds and pools; it may be able to tide over a dry period in this stage. Other beetles found in temporary pools include such species as the black *Agabus bipustulatus*, and *Hydroporus palustris*, a smaller species with yellow marks on the wing covers.

Caddisflies, too, are to be found in temporary pools. *Glyphotaelius pellucidus*, for instance, is often abundant in such places. The adult life of these caddisflies is exceptionally long. They emerge in the summer but their eggs do not start to mature until the autumn, stimulated by the rapidly shortening days. This, it is believed, is an adaptation to life in small bodies of water which, even if they do not dry up completely in the summer, may be deficient in oxygen as high temperatures increase the rate of decomposition of dead organisms and of the respiration of living ones. Hatching in autumn is clearly, therefore, of great survival value.

Such lists as have been published of the animals found in temporary pools are long. In addition to those particularly adapted to this habitat, a whole variety of bugs and beetles may fly in and stay briefly, only to leave again when the pool dries.

Above: An adult mosquito of the genus *Aedes*. Larvae of this genus abound in the smaller temporary pools. The adults attack man fiercely. There are 14 British species of *Aedes*, though a number of these are rare. Two of the species breed in brackish water and are found only in coastal regions and a few inland saline areas. The larvae of a third species are hardly ever found except in the rot-holes in trees.

Below: Apart from the creatures living within the pool itself, visitors to the water edges are frequent. For instance, woodland birds–such as this chaffinch–come to drink and bathe and perhaps to catch any insects hovering over or near the water.



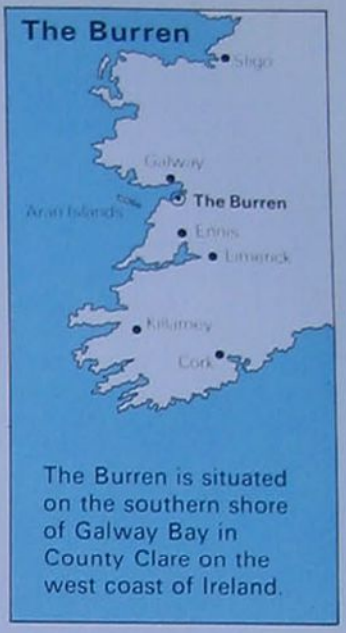
THE BURREN: A BOTANICAL WONDERLAND

No other part of Ireland looks so desolate and empty as the Burren with its bare grey limestone hills and pavements, yet this area has a flora of great international significance.

The name 'Burren' comes from the Irish word 'boireann', meaning a great rock, and is most appropriate for, from a great distance, the landscape of the Burren is dominated by mountains of bare, grey stone. These hills rise to about 300m (1000ft) above sea level and are separated by dry valleys. The great limestone monoliths have been rounded by the action of glaciers, and over hundreds of thousands of years water has dissolved the limestone so that now caves penetrate deep into the hills. On the surface of the hills the water has carved out deep crevices–called scailps locally–which criss-cross the countryside.

Vast areas of the Burren are utterly devoid of soil, so that plants grow only where little pockets of soil have accumulated, such as in the bottoms of crevices and between small rocks. In general, however, the bare limestone has a smooth, level surface; hence the term 'limestone pavement' given to this formation.

Mild climate The climate of the Burren is mild and moist. Rainfall varies with altitude and situation but can range between 1200mm and 1700mm (about 50-70in) a year. The annual temperature range is remarkably small and the average winter temperature is a mild 6 C (43 F). While frosts do occur, they are



The Burren is situated on the southern shore of Galway Bay in County Clare on the west coast of Ireland.

Above: The limestone pavement of the Burren, with a profusion of plants growing in the crevices known locally as scailps. In the foreground is the bloody crane's-bill, with its bright purple-pink flowers. This plant is abundant here, but occurs nowhere else in Ireland. It can be seen in detail in the picture opposite left. Other species to be seen growing in the crevices include burnet rose (to the left of the picture) and bird's-foot trefoil (in the centre).

Above right: The Burren rock-rose is found nowhere else in Ireland except on the Aran islands.

Right: Mountain avens clinging to a rock in the Burren. In late June and July the flowers are replaced by elegant, fluffy seed heads.

seldom severe and snow rarely lies on the ground.

The Burren is, nevertheless, a windy place. The Irish naturalist Robert Praeger described its winter climate as a succession of westerly gales with westerly winds in between! There are no trees, shrubs or hedges on the limestone pavements, as the Atlantic gales act like pruning shears, cutting all plants down to the level of the pavement. (In this, the wind is assisted by goats, which graze throughout the Burren.) Blackthorn, ash, juniper and hawthorn all grow here in the pavement cracks but are cut back near to ground level by the gale-force winds.

Ecological puzzle The fascination of the Burren lies in the intermingling of plants from very different regions and habitats. Plants from the Arctic tundra and high mountains mingle with orchids and ferns more frequently found in warm climates. This perplexing mixture is made more interesting by the rampant carpets of montane and Arctic plants in a mild climate at low altitudes–almost at sea level, indeed.

While these ecological puzzles exercise the discussions of learned botanists, any keen naturalist can find great delight in the brilliant colours and delicate forms of the plants dotted among bare rocks.

Arctic alpines The Burren's symbol is the spring gentian, a plant with startlingly blue flowers that stand about 4cm (1½in) tall above a rosette of small, bright green leaves. From early May until mid-June its five-petalled blossoms are sprinkled through the pavement, grassy areas and stable dunes. Very occasionally, plants with the palest blue, almost white flowers can be found.

Another of the Burren's gems is the mountain avens, whose prostrate stems give rise to pure white, eight-petalled flowers. Both the spring gentian and mountain avens are plants of cold habitats. The gentian is common in alpine pastures throughout southern Europe and occurs in one small area of the

Pennines. The mountain avens grows within the Arctic Circle.

There are two perennial saxifrages growing in the Burren. Along the west coast almost at sea level is the Irish saxifrage, a plant with white flowers and often red leaves. Inland, a very similar species, the mossy saxifrage, forms cushions of green leaves on the pavement and rocky grasslands.

Plants from the south By contrast, some of the Burren's plants come from much warmer habitats. One of the rarest of these 'southern' plants is the Irish orchid, which is abundant around the Mediterranean but restricted in the British Isles to the Burren and a few other places in Ireland, though it has recently been discovered on the Isle of Man. Its flower spikes are composed of numerous small, greenish-cream flowers and the leaves are sometimes blotched with purple.

Several warmth-loving ferns are also found here. The maidenhair fern grows at the bottom of crevices where there is plenty of shelter and a moist environment. Many other ferns inhabit the scailps, including hart's tongue, the sea spleenwort and the rustyback, which is often seen growing on mortared walls.

The wild flowers of the Burren are usually in fullest bloom in late May and early June. Gentians and mountain avens mingle with rock roses and cat's foot, and there are many grasses and sedges, of which the most beautiful is a grass called *Sesleria albicans*, with steel-blue flower spikes.

Heat stores The factors that allow such a remarkable flora to inhabit a landscape as desolate as the Burren's are complicated. Essentially, however, the bare rock seems to act like great storage radiators, absorbing heat in the summer and slowly releasing it through the winter to keep the climate of the area mild. The warm winds from the Atlantic also help to keep frost at bay, so that southern plants like the maidenhair fern can flourish.

Above: Underground streams breaking to the surface of a Burren hillside.

Below: Spring gentian—perhaps the Burren's most beautiful flower.

The alpine plants, on the other hand, grow well there because there is no competition from larger, more vigorous herbs, which are ruthlessly cut back by the wind.

Another important feature of the Burren is the rapid drainage through fractures in the rock. As water percolates through these, the rock slowly dissolves and the cracks become larger until crevices and even caves are formed. The good drainage produces another remarkable feature of the Burren—the vanishing lakes known as turloughs. In winter when the rainfall is highest the water lies in these hollows, but in summer the rainfall is insufficient to overcome the steady seepage underground and the turlough becomes a lush, grassy sward, rich in herbs such as shrubby cinquefoil.

An officer in Oliver Cromwell's army recorded that the Burren was a treeless, waterless place, bare of soil. He did not pause long enough to look at the plants lurking in the scailps or lying snug to the ground over thin soil. From a distance, the hills are nothing more than grey rock, often glinting in the sun after a fall of rain. A close inspection reveals a dazzling array of plants, a real botanical wonderland.

GREENSHANKS: WINTER WADERS

Nesting only in inaccessible places in northern Scotland, the greenshank is mostly a winter visitor here. With its long, sensitive bill and even longer legs, it is a wading bird, well-equipped for life on sea-shores, mudflats and marshes.

There are three species of British bird with 'shank' in their names: the greenshank, the redshank and the spotted redshank. All are waders–birds which feed in shallow water, muddy or boggy areas by probing beneath the surface in search of swimming or burrowing animals. Essential for such a mode of life are a long, narrow, but highly sensitive bill, and long legs which enable the bird to walk on and even sink partway into the mud.

Seasonal appearance The greenshank is larger than the other 'shanks', measuring 30cm (12in), but, as you might expect from its name, a distinguishing feature is the colour of its legs which, like the bill, are olive-green with no trace of red.

In general appearance the greenshank is rather leaner and more lanky than other waders and, especially in winter, is often noticeably pale. At this time of year its underparts are snowy white–from chin to under-tail coverts–and its head, neck and flanks are pale grey with faint darker streaks. Also white, and conspicuously so in flight, are its tail, rump and lower back; together they form a marked contrast to the uniformly grey-brown wings and mantle. In summer, the greenshank's wings and mantle become richly patterned with black and grey, and the breast and flanks become spotted, streaked and barred with black.

Breeding distribution Greenshanks breed from the west coast of the Pacific Ocean right across the Soviet Union and Northern Europe to Scotland, with just a single and understandably secret breeding site in Ireland. In Scotland about 600 pairs are believed to nest each year, but these are all in wild, inaccessible moorland areas in the Highlands, Skye and the Outer Hebrides. For most birdwatchers the easiest place to see greenshanks is, therefore, at their coastal migration and wintering sites. Most fly far to the south for winter.

Britain and Ireland, however, can boast a wintering population of about 600 greenshanks, and it is interesting to speculate where these come from. In the absence of clear information from ringed birds, the best clues

Below: Greenshank on a heath-clad hill. The bill is very slightly upturned but nobody knows why. It has been noticed that some other species which chase active aquatic prey (as does the greenshank) have the same characteristic. One advantage may be that the tip of the bill can be brought parallel with the water surface without wetting the head feathers. The upward curve may also bring the tip more directly into the bird's line of sight and so assist hunting.

Above: A greenshank with eggs. Many greenshanks nest beside a log or rock, perhaps to gain some shelter from wind and rain.

Greenshank (*Tringa nebularia*). Winter visitor, and also scarce breeder in northern Scotland. Sexes alike. Length 30cm (12in).

Below: Newly hatched greenshank chicks in their nest. Four is the usual number to find in a brood.

are provided by examining the arrival and departure dates of greenshanks in different areas. Thus, our wintering birds begin to leave the coasts in late March, just when the first breeding birds arrive in Scotland. All have left by late April, the time when most Scottish birds are selecting nest sites. In contrast, greenshanks arrive in Scandinavia in late April and May, coinciding with a marked passage of greenshanks in southern and eastern England. The obvious, though unproven, conclusion is that only Scottish breeding birds winter in Britain and Ireland, while Scandinavian breeding birds fly further south, merely passing through en route.

Feeding habits For its size, the greenshank is an active and agile feeder, tending not to resort to slow methodical probing over large expanses of mud like some species. Instead, it prefers to hunt for shrimps and small fishes, such as gobies, at the water's edge. Often, the technique is to dash forward with head and neck outstretched and bill half-open, ready to seize the victim.

During the breeding season, tiny brightly coloured leaf beetles from waterside plants often form the bulk of the diet. This discovery was made when scientists examined greenshank pellets, which often glistened with the beetles' wing cases. Dragonfly nymphs, pond skaters and water boatmen also featured regularly among the remains as, too, did remnants of fishes, frogs, newts and lizards. It is thought that, in their acidic breeding grounds, greenshanks may sometimes have difficulty in gathering sufficient calcium for their eggshells–these unusual food items helping to make good the lack.

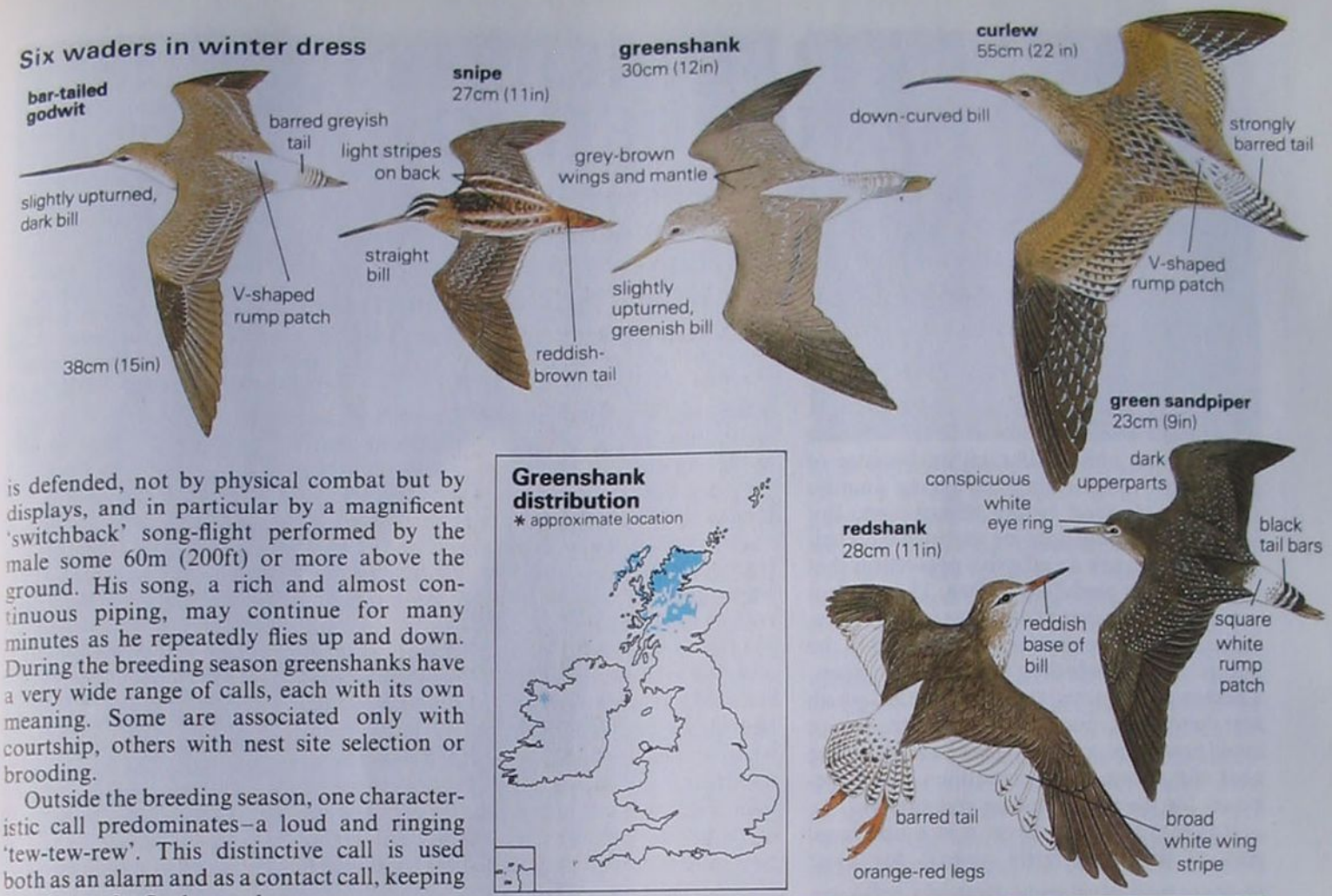
A greenshank-watching family Much of our detailed knowledge of greenshanks in summer comes from the work of a single family–the Nethersole-Thompsons. For many years this family has lived in greenshank country–first in the Spey Valley and latterly in Sutherland. So detailed is their knowledge that they recognise individual greenshanks, having followed the fortunes of some birds for 11 consecutive years.

That each greenshank has its own personality is interesting in itself, since we tend not to notice this in wild birds. A greenshank may, for example, have its own way of approaching the nest, or perhaps a definite 'accent' to its voice. However, the most useful–and least subjective–differences relate to eggs and egg-laying: their size, colour, shape and time of laying may all be quite distinctive.

Four types of territory The Nethersole-Thompson family also found that greenshanks defend up to four different types of territory, depending on the terrain and the stage of the breeding cycle. Initially there is the mating territory, usually a small loch or bend in a river, to which the male can attract a female and court her in peace without neighbourly intrusions. Then there is the nesting territory, which contains a choice of suitable nest sites, some rocks or raised ground for lookout posts, and at least some good feeding spots. The cock greenshank leads his mate to various possible hollows suitable for the nest and from these the hen makes her choice.

The third type of territory is a separate feeding territory, though not all pairs have one. These may be as much as 4km (2½ miles) away, and it is here that the off-duty parent can retire to regain strength. Finally, when the chicks hatch after 25 days of incubation, the parents defend a small area in which the growing family can feed without interference.

Displays and songs Each of these territories



is defended, not by physical combat but by displays, and in particular by a magnificent 'switchback' song-flight performed by the male some 60m (200ft) or more above the ground. His song, a rich and almost continuous piping, may continue for many minutes as he repeatedly flies up and down. During the breeding season greenshanks have a very wide range of calls, each with its own meaning. Some are associated only with courtship, others with nest site selection or brooding.

Outside the breeding season, one characteristic call predominates–a loud and ringing 'tew-tew-rew'. This distinctive call is used both as an alarm and as a contact call, keeping members of a flock together.

Of all the ritualised displays of the greenshank, those involved with pairing are perhaps the most thrilling. Each gesture is vital in the sequence, and each fresh bout of displaying builds up the pair bond, until the day comes when mating can be achieved. In one important and conspicuous component,

Below: A wading greenshank in winter plumage. At this time of year the wings and mantle are uniformly grey-brown; in summer they become richly patterned with black and grey. Notice the conspicuous white belly.

Feeding techniques

The greenshank has two methods of stirring potential prey into action. In one, called mowing, the bird walks forwards, repeatedly sweeping its bill from side to side with the tip just touching the mud. The second, performed in shallow water, is a most remarkable high-stepping, dance-like movement (below).

the cock chases the hen in a rapid, twisting, even figure-of-eight flight low over loch or moor, sometimes rising to a great height.

The actual mating takes place on the ground, and here again calls and gestures from both partners are vital to the success of the occasion. While the hen stands almost motionless and somewhat dipped forwards, the cock raises and vibrates his wings high over his head, making 'chipping' and 'growling' sounds while he slowly struts towards her. He displays his dazzling white rump patch by fanning his tail and bowing forward, and flaps his wings quicker and quicker until he gracefully floats on to the hen's back and they mate. They often pair for life.

THE NOCTURNAL LIFE OF THE HEDGEHOG

There is still a great deal to be learned about the night-time activities of hedgehogs, welcome and familiar visitors in many parts of the country. They may travel up to a mile in a night's wanderings, often stopping to take bread and milk and numerous garden invertebrate pests. But is this the exception or the rule?

Hedgehogs are typically nocturnal animals. Those seen wandering about in the daytime are behaving abnormally, either because of sickness or because they are young animals seeking extra food before hibernation. But why should hedgehogs be nocturnal? Their spiny coat is such an effective protection that they have few predators to fear. They do not really need the cover of darkness (unlike mice, for example). The answer probably lies in the nature of the hedgehog's main food items. These include worms, slugs and beetles, which are themselves nocturnal–partly to try to avoid predators, and partly because nights are cool and damp, these conditions being necessary for their own feeding and survival.

It is easy for us to forget that a nocturnal way of life is perfectly normal for most mammals. It is humans who are among the exceptions and it is diurnal behaviour that needs explanation, not nocturnality. In fact, the very first mammals to evolve probably needed to be active under the protective cloak of darkness and the hedgehog, as one of our most primitive and ancient mammals, has sinply kept up the habit, having had no good reason to change.

Life in the dark The hedgehog is well adapted to life in darkness. Its principal sense is smell. It can probably recognise other hedgehogs individually by smell rather than sight, and most of its food is found by sniffing about and poking its nose into every likely spot. Its hearing is acute too: its ears are so close to the ground that worms and other prey, silent though they may seem to us, may

Right: Hedgehogs are usually thought of as being rather slow animals, trundling about like clockwork toys. So it comes as a surprise to learn that they travel over many acres each week as a matter of normal activity. On some nights male hedgehogs may cover two miles in the course of their wanderings. In fact hedgehogs are surprisingly athletic. They can run faster than a human can walk and they can dig, swim and even climb fences and walls.

Below: Tens of thousands of hedgehogs are probably killed on our roads every year, particularly in April and May, the breeding season. Two thirds of these spring-time casualties are males. The male and female young of the year are killed on the roads in roughly equal proportions, but by autumn three females are being run over for every one male. Despite the numerous deaths, many more survive.

ensily give away their presence as they squeeze between grass roots and disturb crumbly soil. Just such tiny sounds may alert a hunting hedgehog. Certainly foraging hedgehogs often stop still, perhaps to listen carefully, before resuming their sniffing and close inspection of likely hiding places in which they might find food.

Hedgehogs also use their eyes, but probably these are most helpful for detecting distant objects silhouetted against the sky. They are alert to movements, but ignore a stationary person, even when very close. Like most nocturnal animals, hedgehogs are probably unable to tell one colour from another. Blind hedgehogs are also occasionally found, confirming that eyesight is not essential and that smell and hearing are the more important senses for hedgehogs.

Each hedgehog travels about a mile in a night's wanderings; sometimes revisiting the same areas as on the previous night, and sometimes going somewhere new. Males seem to be much more active than females. In the course of a few weeks their regularly used home range may be 30ha (75 acres) or more in extent. By contrast, females usually operate within an area only one third that size. These figures apply to hedgehogs living in open grassy habitats; those that live in dense woodland or town gardens may move about rather less.

Sharing territory Hedgehogs do not appear

Above right: A hedgehog dropping is likely to contain the remains of beetles, caterpillars and earthworms in large quantities, as well as earwigs, slugs, small mammals and millipedes.

Below: Gardens offer the hedgehog a very varied menu of invertebrates. Many of the prey items that it finds and eats among flowerpots and rockeries are destructive garden pests, so the hedgehog is the gardener's friend.

to be territorial–one reason why several may be seen at the same time in a single small garden. They wander widely and freely without bothering to defend territory and keep out other hedgehogs. There is probably no need: food is usually fairly plentiful and easy to get, especially as hedgehogs are not fussy about what they eat and will consume almost anything edible. Why waste energy trying to keep other hedgehogs away, especially as, in the dark, it is more difficult to know where intruders might be? The exception to this peaceful behaviour comes when hedgehogs actually meet and confront each other. A brief scuffle may then ensue, with one animal driving away the other. Such contests are often observed when hedgehogs come to bowls of bread and milk, but they probably have more to do with establishing social dominance than with trying to defend a territory for the exclusive use of a single hedgehog.

Even though they do not defend a private patch of ground, many hedgehogs (especially females) remain in the same general area for long periods and even from one year to the next. Despite this, it is not easy to say how many hedgehogs live in a particular place. There are always some coming or going and it is difficult to keep track of them all. People who think they have two or three regular hedgehog visitors to their garden have marked the animals and found to their

Left: The hedgehog's most obvious characteristic is its spiny coat, which leads people to assume that it is closely related to other conspicuously spiny animals such as porcupines. In fact porcupines are rodents (like squirrels and rats). Australian spiny anteaters and Madagascan tenrecs also have spines, but they are not related to hedgehogs either. By chance during their evolution they have come to resemble each other.

Right: Breeding females often have a large nest made of leaves, grass, paper and other debris, in a secure place such as under a garden shed or deep in a bramble thicket. Male hedgehogs play no part in raising the family and live alone, as do non-breeding females. These solitary animals often do not bother to build a proper daytime nest, especially in warm weather. They simply retire to a dry spot under some grass or leaves, shuffle round a few times and go to sleep.

astonishment that five or more may come in one evening and over a dozen in a month. This might suggest that hedgehogs live at a high population density, maybe one per 10-20 square yards.

However, it would be quite wrong to suppose that 12 hedgehogs all live permanently in a small garden. In fact they come in from a wide area and they are also likely to spend much time in neighbouring gardens too. In suitable habitats there may be an average hedgehog density of one per hectare (2-3 acres), but in poorer habitats there will be many fewer. The truth is that we just do not know; there is no scientifically accurate way of carrying out a hedgehog census and measuring population density. For this reason, we cannot say whether hedgehogs are increasing in numbers or in decline, nor can we accurately compare population densities in one habitat with those in another.

At the end of a night's wanderings, the hedgehog retires to a nest to spend the day asleep. Curiously, it does not necessarily choose a quite place to spend the day, and may use a daytime retreat right beside a busy road

Below: A radio-tagged hedgehog taking bread and milk and (right) a young hedgehog. Pregnant and nursing females in a cold spell, and young animals seeking extra food in a cold autumn, can all benefit from this food. In dry summers it may save many from dying of thirst, too.

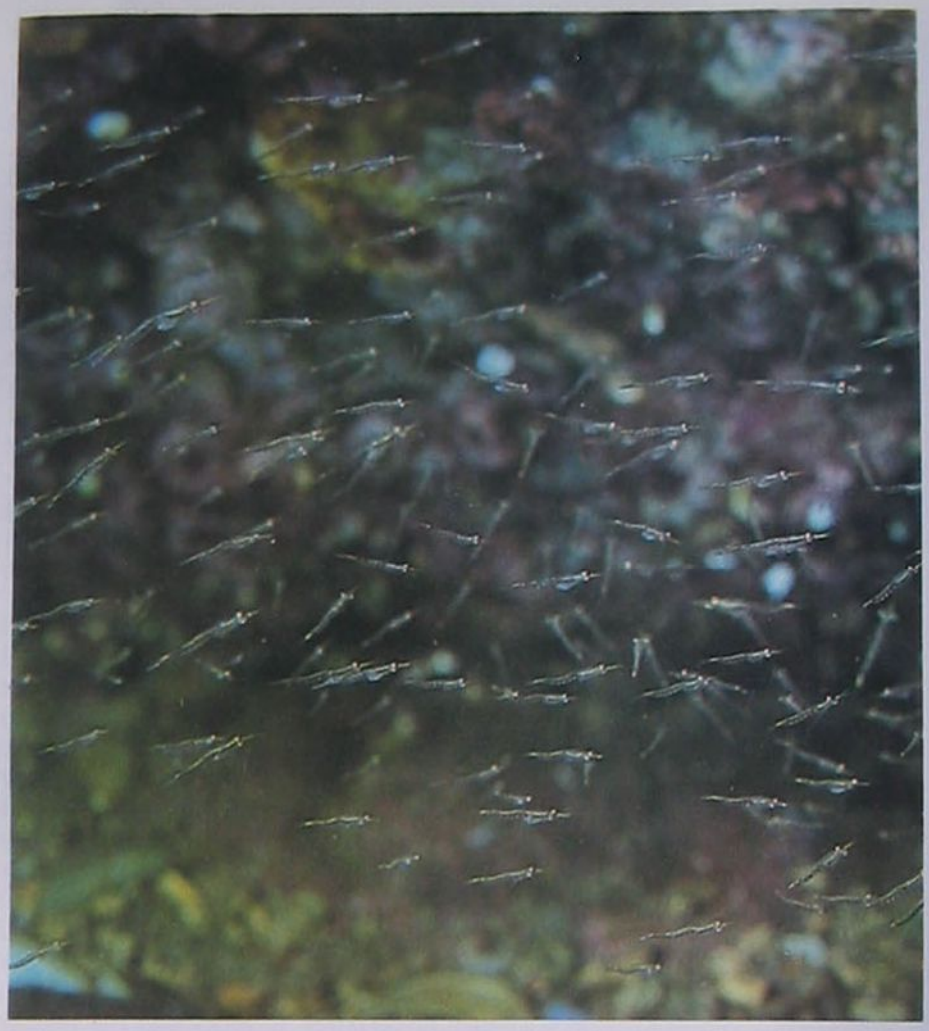
even when traffic noise is only a short distance away. Often the hedgehog will sleep in the same place for several days in succession, then try somewhere else, perhaps going back again to the original place. Meanwhile, in its absence, the site may have been briefly occupied by another hedgehog, although adult hedgehogs do not normally share a nest at the same time. A single hedgehog may use a dozen or more nests in a few weeks during the summer. In winter, the pattern is quite different; hibernating hedgehogs usually stay put for longer periods and do not move about nearly so much. They also build larger, more weatherproof nests in winter than in summer.

Bread and milk Many people put out bread and milk for hedgehogs and it might be expected that this would disrupt the normal patterns of hedgehog activity. If food is always abundantly available in a garden, why should a hedgehog go anywhere else? Could it be that bowls of bread and milk act like hedgehog-magnets and cause the animals to wander about less widely and maybe nest closer to the garden, or perhaps within it? People who regularly put out food for hedgehogs may be causing the hedgehog population to be clumped round their garden and not evenly spread out as would be the case under natural circumstances.

It is certainly true that hedgehogs like bread and milk. It is also true that they will travel long distances (a quarter of a mile for example) to include a visit to a garden bowl in the course of their wanderings. However, they do not become addicted to artificial food, nor heavily dependent on it. Hedgehogs certainly make use of food put out for them and they also pick up scraps from around bird tables and perhaps raid plates of cat and dog food; but this is all in addition to their normal feeding activity. Such items are a supplement to their natural diet, not a replacement. So when householders go away and the regular hedgehogs do not get fed, starvation and misery do not follow; the hedgehogs simply feed on something else. Their 'go anywhere, eat anything' casual life-style means that they are very flexible animals.

The exception to this comes in periods of drought or cold weather when natural food is hard to get. At such times, plates of table scraps, bread and milk put out in gardens may save many hedgehogs from starvation. Even where extra food is regularly provided, the hedgehogs do not cluster round it; instead they live as near as possible. Many choose a daytime shelter 200 yards or more away, even though many equally suitable resting sites are available nearer to the food.

Below: It is a pleasure to watch hedgehogs this close to the house, but remember they can drown in a pond or swimming pool. A piece of wood acting as a raft, or chicken wire at the side of the water will help them back to land. A pile of leaves helps with hibernation (right).



THREE SHRIMPS OF THE SEA

Many more types of shrimp live round our coast than the ones that end up on our tables. Three such are the krill, opossum and mantis shrimps.

Above: A shoal of opossum shrimps in the waters off Orkney. Like krill shrimps, they are an important food for many marine animals. One species is made into a paste called 'chervé' to be used as bait for mullet.

Below: A mantis shrimp, with its stalked eyes at the front of its head and its large spined claw, seen here folded and ready for striking. At the back of the shrimp, along its jointed abdomen, are five pairs of swimmerets.

The North Atlantic is home to six species of krill shrimp, though the layman is only likely to see them among catches of fish landed on the quaysides of our larger fishing ports. Most krill shrimps have no common name but the conspicuous eyes of one species, *Meganyctiphanes norvegica*, is well known to Scottish fishermen, who gave it the Gaelic name 'suil dhu', meaning 'black eyes'. These eyes are used chiefly for sensing changes in the light level–the species lives at depths where only blue-green light can penetrate and the eyes are, therefore, sensitive only to these colours.

Krill anatomy Just behind the eye of a krill shrimp lies the head region, which is covered with a thin shell (the carapace) that leaves the gills beneath exposed and prominent. The front limbs are thin, lack claws and are divided into an inner and an outer branch; the outer is whip-like and used by the krill shrimp to direct water currents into a 'food groove' lying between these limbs. There are seven visible pairs of limbs, and an eighth pair which is reduced and cannot be seen. Food particles–smaller planktonic organisms and detritus derived from the sea-bed–are strained off by numerous hairs covering the front limbs and the other mouthparts.

The abdomen is flexible and consists of six segments. Five of these each have a pair of limbs called swimmerets that are used for swimming and to pass currents of water over the gills.

A particularly interesting feature of the krill shrimp's anatomy is the luminescent organs distributed on the eyes, at the base of the seventh pair of front limbs, and between each of the first four pairs of swimmerets. Except for those in the eyes, all of these organs contain a lens, light-producing cells and a reflecting pigment. The light produced collectively by the enormous shoals of krill found in the dark depths of the sea is sometimes brighter than the intensity of sunlight reaching these depths–even at mid-day.

Vertical migrations An interesting behaviour trait of krill shrimps is their habit of making regular vertical migrations. In the case of *Meganyctiphanes*, which has been well studied, the animals live near the sea-bed by day but begin to rise towards the surface of the sea as dusk approaches.

Such migrations allow the krill shrimps to vary their diet, since the food available to them differs with depth. Furthermore, the downward migration allows them to avoid predators while the upward migration allows them to spread to other areas of the sea via water currents.

Life-cycle The majority of krill shrimps shed their eggs into the sea where they hatch as minute so-called 'nauplii', looking quite unlike their parents. They pass through five larval stages, becoming progressively more shrimp-like in appearance, until in the post-larval stage all the legs are developed and the

shrimp takes on the shape of the adult.

Krill shrimps are of considerable importance in the food chains of many higher marine animals–indeed, the blue whale feeds exclusively on them. They also form the major food for a great number of commercially important fishes. Consequently the economics of many fisheries depend upon krill supplies.

Opossum shrimps This group of crustaceans resembles krill shrimps in some respects but the ones found in inshore waters are distinguished by a combination of features: the front limbs are developed for swimming rather than feeding and the roughly cylindrical abdomen bears small, hardly functional swimmerets. But the most important feature, and one that separates opossum shrimps from all others, is that the female develops a brood pouch, called a marsupium, in which she incubates her eggs.

A common inshore species is *Praunus flexuosus*, one of three species sharing the common name of chameleon prawn because of their ability to change colour. This species can be found in considerable numbers in rock pools and among beds of eel-grass. When disturbed the shrimps escape by springing backwards very quickly; the movement can be so sudden and forceful that they may be thrown out of the water.

Chameleon prawns, along with other opossum shrimps, are filter feeders but they can capture small moving animals and they also feed on carrion.

The majority of opossum shrimps are marine but a few species live in brackish water and one or two in fresh water. Of the marine forms, most occur in shallow waters, but the large *Gnathophausia ingens* (length 16cm/6½in) descends to depths of 3500m (1800 fathoms) in the Atlantic.

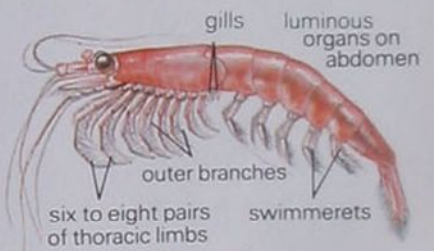
Breeding habits The chameleon prawn, *P. flexuosus*, mates at night, the males being attracted to females that have recently moulted. In British waters breeding takes place between February and the end of September. The eggs are incubated in the female's marsupium for about three weeks, in the summer between 27 and 40 being brooded at one time. As the year progresses, the number of eggs becomes lower and the incubation period longer. A fully grown female may produce three broods in a year, and lives for about 18 months. The young lack a larval stage and, when released from the marsupium, look much like the adults.

Mantis shrimps Mantis shrimps–so-called after their mantis-like second pair of legs–are uncommon in British waters, the majority of species being tropical or subtropical. They are predatory creatures, living in burrows or just beneath the surface of the sand, and they use their mantis-like limbs (which are equipped with sharp spines) to spear soft-bodied prey.The shrimp remains concealed until it selects its victim, which it does by sight; then it darts out with phenomenal speed and strikes its victim with its claw. This strike is one of the fastest animal movements known, taking between four and eight thousandths of a second, so that the claw itself moves at a speed of more than 10m (33ft) a second. The impaled prey is pulled backwards into the burrow and torn apart by the mantis shrimp's mouthparts.

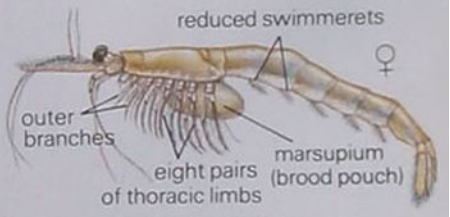
Above: The chameleon prawn, *Praunus flexuosus*, has a characteristic manner of swimming: it hangs almost vertically in the water. Notice the developing brood pouch on this female.

Three types of shrimps

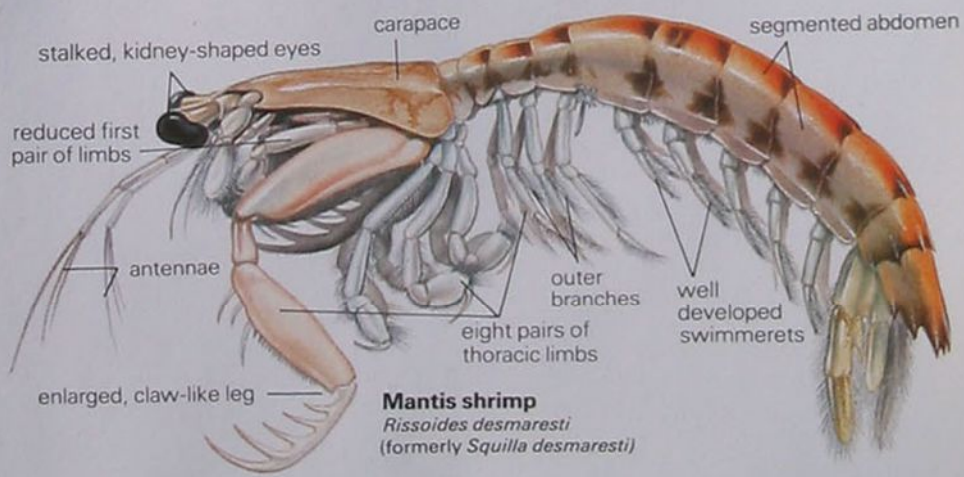
Krill, opossum and mantis shrimps have similar body structures: two prominent eyes in front of a carapace that covers all (or most) of the thoracic or body segments, and finally a segmented abdomen. Both thoracic and abdominal segments bear limbs, which may be used for swimming, feeding or grooming. Krill shrimps can be distinguished from the other two groups by a combination of exposed gills and uniform front limbs; opossum shrimps by their extremely small swimmerets; and mantis shrimps by their distinctive large claw.



Krill shrimp



Opossum shrimp



Mantis shrimp
Rissoides desmaresti
(formerly *Squilla desmaresti*)

VETCHES: CLIMBING GRASSLAND PEAS

One of the most familiar sights of the summer along roadsides and on chalk grasslands are the small, brightly coloured, pea-like flowers of vetch, a group of mostly weak-stemmed climbers that hang on to neighbouring plants by means of long tendrils.

Right: The bitter vetch (*Vicia orobus*) is the only member of the true vetches to lack tendrils on the tips of its leaves. A rare species of meadow and scrubland, it flowers from June to September.

A great many plants share the common name of vetches but the true vetches, or tares as they are also known, belong to the genus *Vicia*. This genus belongs to the pea family, Leguminosae, as can be clearly seen from the structure of vetch flowers, which have the same petal arrangement as other pea flowers: a pair of petals called the wings sit below and to each side of the standard petals; below these is the keel, consisting of two petals partly joined together at the base. Concealed within this structure is the stigma, ten partially joined stamens and a nectary–the nectar-producing gland.

In vetches the flowers may be borne in clusters on a stem, in pairs, or on their own, and their colour varies from blue, through shades of red and purple, to yellow. Bees find the attractively coloured flowers, with their scent and sweet nectar, irresistible and land on the keel searching for the nectar. Their weight pushes down the keel, exposing the stamens and stigma, and pollen from the stamens is deposited on their backs. In turn, pollen from a previously visited vetch flower is transferred from the bees' bodies to the stigma, thus effecting pollination.

Robber insects Some insects, particularly a species of bumble bee called *Bombus terrestris*, adopt underhand methods of obtaining the flower's nectar. They alight on the stalk of the vetch and bore a hole in the base of the flower, through which they suck the nectar, thus obtaining the food without pollinating the flower.

Some species of vetch solve this problem by producing nectar both inside the flower and at the base of leaf-like appendages–the stipules –found on the stem. The latter are referred to as decoy nectaries and appear to the naked eye as black spots. Insects which would otherwise steal the floral nectar are attracted instead to the stipules' nectaries.

Leaf arrangement The leaf of a vetch consists of small leaflets arranged along each side of a central stalk–as they are on many pea plants. The number of leaflets on each leaf varies from species to species. The Bithynian vetch, for example, may have as few as one or two pairs to a leaf, while the tufted vetch may

Above: Being members of the pea family, all vetches and vetchlings bear fruits in the form of long narrow pods, which split open when mature to release the seeds. The fruits and flowers shown here are those of the meadow vetchling (*Lathyrus pratensis*).

Right: A red form of kidney vetch (*Anthyllis vulneraria*) found near the coast.

Opposite page: Tufted vetch (*Vicia cracca*) scrambling over a hedgerow.

have as many as a dozen pairs of leaflets.

Unlike many plants in the pea family, vetch leaves do not end in a single leaflet but in a modified leaf called a tendril, which many species use to cling on to other plants. However, there is an exception to the general rule–the bitter vetch, which lacks tendrils.

Vetch habitats Vetches can be found in a wide range of habitats, including woods, grassland, cliff tops, coastal sands and shingle. The majority, however, prefer sunny grassy places, such as roadside verges and south-facing chalk banks. In contrast, the Bithynian vetch and the yellow vetch are more or less confined to our southern coastline where they grow on cliffs; the yellow vetch, in particular, favours coastal shingle.

Two of the commonest species are tufted vetch and bush vetch. Both are perennials with flowers borne in clusters called racemes, appearing along wayside verges and hedgerows from June through to August. The tufted vetch sometimes has as many as 40 purplish-blue flowers in a cluster, while the purplish-pink flowers of the bush vetch are less profuse.

Despite its common name, the wood vetch can be found growing on shingle, but it mainly inhabits woods and also rocky places inland. This handsome perennial may bear as many as 18 flowers on a raceme, each being white and marked with attractive blue or purple veins.

Another species often found in rocky woods is the bitter vetch, a stout-stemmed perennial with between six and twenty flowers on each raceme. The flowers are similar to those of the wood vetch: white with purple veins.

The common vetch, despite its name, is not the most common member of this group

Above: A close-up view of the flowers of tufted vetch shows their similarity to others in the pea family, such as broom, gorse and bird's-foot trefoil.

Right: Yellow vetchling (*Lathyrus aphaca*) lacks true leaves, having instead broad enlarged stipules.

Below: Everlasting pea (*L. latifolius*) colonizing a railway embankment.

–though it is widespread–nor is it a native of Britain. It was introduced here as a fodder crop and is often seen naturalised in waste places and the margins of cultivated fields. Its small, pale purple flowers are usually borne in pairs in the leaf axils. At one time, the seeds were cultivated commercially and sold as food for poultry, doves and pigeons. Ironically, the common vetch is the only British plant in the genus that is at all poisonous, though curiously only the occasional plant is so.

Another species of *Vicia* widely cultivated for many centuries is the broad bean, or horse bean, whose large seeds are eaten as a vegetable. It occasionally escapes to the wild but rarely persists long enough to be considered naturalised in this country.

Annual tares Three closely related species of *Vicia* share the common name of tare: the hairy, smooth and slender tare. The last two are the most closely related of the three. Both have pale blue flowers, unbranched tendrils and relatively long leaves. They are found mainly in the south of Britain, the slender tare having a more local distribution and being most common in East Anglia.

The hairy tare is noticeably different from

the other two, with its dirty white to purplish flowers, shorter leaves and branched tendrils. It is often seen as a tangled mass in hedgerows and, as a rampant weed of cornfields, it used to be known as strangle tare. It has a scattered distribution throughout the British Isles, and is commoner in the south. The name 'hairy' tare comes from its downy pods.

Britain's vetchlings Among the closest relatives of the vetches are members of the genus *Lathyrus*, commonly known as vetchlings or peas. They are very similar to the true vetches, the two genera sometimes being difficult to distinguish, but they can usually be told apart by looking at the leaves and stems. Plants in the genus *Lathyrus* have, in most cases, fewer leaflets to a leaf and their stems have small wings running along the edges.

One of the most common and widespread species in this group is the meadow vetchling, a scrambling, climbing plant of hedgerows whose rich yellow flowers often cast a golden hue over country lanes and pastures during the summer months. But perhaps the most distinctive species is the yellow vetchling. This plant lacks true leaves; instead it has very large stipules shaped roughly like a spearhead. Yellow vetchling is fairly rare in Britain, largely because a great proportion of the young plants are killed by frosts during the winter. Not surprisingly, the species is most common in southernmost England.

Other vetches Finally, there are a few species that have the common name 'vetch', but do not belong to either of the genera *Vicia* or *Lathyrus*. One of the best-known of these is the kidney vetch, in the genus *Anthyllis*. This plant is easily recognised by its dense head of deep lemon-yellow flowers protruding above a ring of conspicuous white and woolly calyces. Kidney vetch is found throughout the British Isles, but it is more common on shallow calcareous soils, especially those near the sea.

The horseshoe vetch, in the genus *Hippocrepis*, has golden-yellow flowers borne on long-stalked heads. The pods have a curiously sinuous appearance and look like streamers blowing in the wind. They sometimes break up into horseshoe-shaped segments.

The milk-vetches belong to the genus *Astragalus*. The purple milk-vetch is one of the most attractive of this group, bearing deep purple flowers from May to July. It is confined to the eastern counties of England and Scotland, and occurs in just one locality in Ireland, the islands of Aran off the west coast.

A smaller and less attractive species is the alpine milk-vetch. This plant is extremely rare, being found only on a few Scottish mountains. It flowers in July, producing pale blue blooms.

Above: With its white petals marked with purple or blue veins, wood vetch (*Vicia sylvatica*) is one of the most attractive plants in the pea family.

1 Hairy tare (*Vicia hirsuta*). Hedgerow plant flowering May to August.
2 Smooth tare (*Vicia tetrasperma*). Hedgerow plant flowering May to August.
3 Yellow vetch (*Vicia lutea*). Coastal species flowering from June to September.
4 Purple milk-vetch (*Astragalus danicus*). Grassland and dune plant flowering May to July.
5 Common vetch (*Vicia sativa*). Hedgerow and scrub plant flowering May to September.

Vetches and their allies

TICKS: CLINGING BLOOD-SUCKERS

All ticks are blood-sucking external parasites of land vertebrates. In some cases heavy infestations can lead to death, but more usually ticks cause discomfort and may transmit disease. Fortunately this does not often occur in Britain.

Together with mites, ticks belong to the Acari, a subclass of the Arachnida. There are about 800 species of ticks in the world, and at each life stage all are blood-sucking external parasites of land vertebrates. Most species occur in tropical areas, a few have been found in such extreme places as birds' nests in circumpolar regions and in desert areas where few other blood-sucking parasites survive, while others are significant pests in temperate regions.

Heavy infestation of a host can cause ill-health–sometimes even death–through blood-loss and through irritation or secondary infection of the wound. However ticks cause most harm in their role as reservoirs for, and transmitters of, a variety of disease organisms, including bacteria, viruses and micro-organisms called rickettsiae.

Detecting a host Ticks are generally much larger than mites, being 2-5mm long as unfed individuals but up to 3cm (1¼in) long after a full meal. The two groups share certain characteristics, such as an external skeleton of cuticle and hair-like setae (sensory organs) on the body and appendages. The eggs of both groups hatch into six-legged larvae, followed by eight-legged nymphs and adults.

Above: The hedgehog tick (*Ixodes hexagonus*) parasitises a wide range of small mammals but has not been recorded on birds. In urban areas it is common on dogs and cats.

For ticks, however, the pressures of a necessarily parasitic way of life, and the priority of finding a suitable host, have resulted in the development of certain unique characteristics. One of these is Haller's organ, found on the last segment of the forelegs. This small organ possesses setae sensitive to humidity, smell, carbon dioxide levels, temperature and vibrations. (Most ticks also have cuticular structures on the body which enable them to distinguish between different light intensities.)

Detection by the setae of these stimuli may signal the presence of a host and this triggers off behaviour that maximises the chances of contact. The tick's ensuing behaviour can be divided into two strategies; hunting and ambushing. A hunter moves towards the host following the trail of the stimuli, but ambushers, by contrast, put themselves in a position where hosts are likely to pass, for example at the tips of vegetation along animal runs. When an approaching host is detected the tick takes up a 'questing' posture, waving its front legs in the direction of the stimuli.

Obtaining a blood meal Once on the host, the next problem is to penetrate the skin so that the tick can feed, and then to remain attached until the meal is completed. The mouthparts are well adapted for this.

The most prominent region of the mouthparts is the hypostome, a large finger-like structure armed with backward pointing teeth and a groove running along the length of the top surface. The two chelicerae (fangs), sited behind the hypostome, consist of a long rigid shaft ending in a toothed pincer.

The tick begins feeding by straightening its back legs and lifting its body at an angle of 45°. It then punches the skin with its chelicerae by a shearing action of the pincers and passes saliva, containing anti-coagulants, into the wound via the hypostomal groove. This saliva helps to soften the tissues and to prevent the blood clotting; if disease organisms are present on the tick these also pass into the host

Tick mouthparts

Soft tick close-up of mouthparts

Left: The soft ticks (Argasidae) remain in their hosts' nests. These ticks have poorly developed mouthparts as they do not have to cling on to their hosts on the move.

Hard tick close-up of mouthparts

Left: The hard ticks (Ixodidae), like the sheep tick, have developed mouthparts possessing a well-armed hypostome which helps to secure them.

with the saliva. By rocking its body the tick gradually works its hypostome into the wound.

In many species puncturing is followed by the secretion of a 'cement', which flows into the host's tissues and gradually surrounds the mouthparts. This cement and the hypostomal mouthparts anchor the tick to its host during feeding. The tick sucks the blood up along the hypostomal groove and stores it in its branched gut.

Hard ticks Three tick families exist, but in Britain we have representatives from only two families–the Ixodidae (hard ticks) and the Argasidae (soft ticks). The Ixodidae are characterised by a rigid cuticle, a thickened dorsal shield (the scutum) and well-developed mouthparts. Some ixodids are 'one host ticks', feeding on the same hosts for their entire life-cycle. Others are 'two host' species–the larvae emerge and moult on one species of host but then the nymphs drop to the ground to moult and new hosts are sought by the adults. Most species in Britain however, are 'three host ticks', each stage requiring a different host individual and each moult occurring on the ground.

Soft ticks By contrast the argasids (soft ticks), which have a leathery cuticle, no scutum and poorly developed mouthparts, parasitise animals which periodically return to a particular place such as a nest or burrow. Only the larvae are carried on the host, remaining attached for several days while they feed; the nymphal stages (of which there are up to eight) and adult stages remain in the retreat having to feed rapidly (two minutes to two hours) and intermittently whenever the host returns to rest.

As the host is relatively still when feeding takes place, there is less danger of an argasid tick being dislodged and the mouthparts are not so well-armed as those of the ixodids. When an argasid tick feeds its body weight increases up to ten times and, as it occurs very rapidly, the cuticle has to expand quickly to cope.

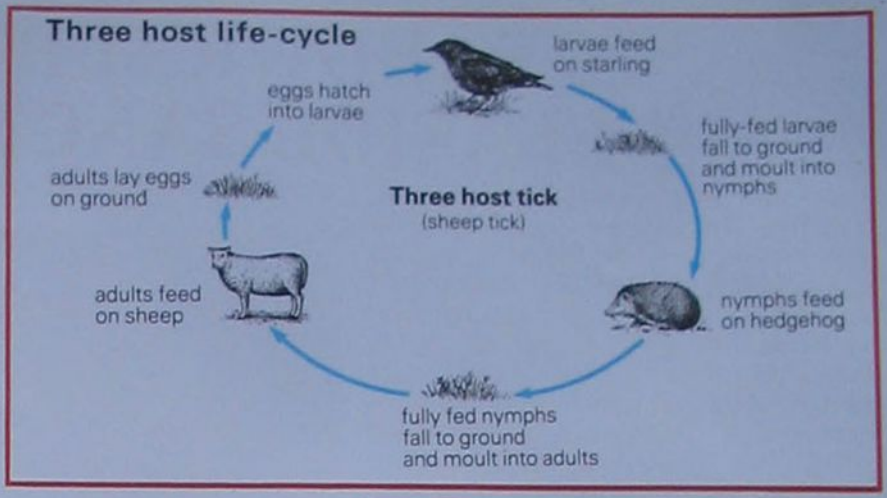
The female lays her eggs in or near the retreat, while the larvae drop from the host there. Consequently, the problems of finding a host are not so acute as for ixodid ticks; mortality is also lower and it is therefore not necessary for so many eggs to be laid–usually they number a few hundred.

The uncertainty of the host's presence, however, demands that argasids are able to survive for long periods on one meal. This they do by drastically reducing their metabolic rate–incidences of individuals fasting for up to ten years have been recorded.

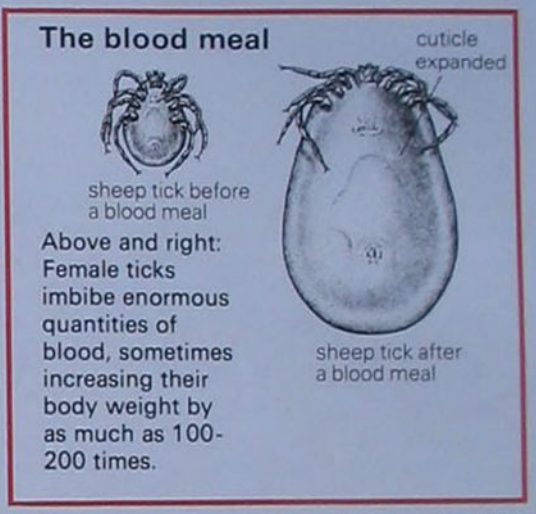
Tick species In Britain 23 species of ticks occur, 20 of which are ixodids. The most common is the sheep tick, a three host species which mainly parasitises sheep and cattle, but has also been recorded on most British mammals and birds. It is a vector of louping ill–a serious viral disease of sheep–and red-water fever from which cattle suffer. Sporting and other working dogs are often infested with the dog tick *Ixodes canisuga*, a species which also parasitises foxes, and seems well adapted to the dry conditions found in kennels.

A number of ixodids are primarily parasites of birds. *Ixodes uriae*, for example, infests seabirds–mainly puffins, guillemots, razorbills, cormorants and fulmars–and is often found in large quantities in the turf on the cliff ledges frequented by their hosts. Jackdaws have been sighted feeding on them with relish.

Only a few argasid ticks occur in Britain, by far the most common being *Argas vespertilionis*, a bat tick.



Above: Most tick species in this country are 'three host ticks', each stage of their life requiring a different host individual and each moult occurring on the ground. The species of the host may vary in each stage–thus one tick may choose a hedgehog for the nymphal stage, while another individual of the same species may feed on a dog. Mortality is high as host hunting is a hazardous occupation often ending in failure. To compensate for this the female lays many eggs–sometimes as many as 18,000 at a time.



Above and right: Female ticks imbibe enormous quantities of blood, sometimes increasing their body weight by as much as 100-200 times.

Below: The sheep tick (*Ixodes ricinus*) primarily parasitises sheep and cattle. After a blood meal the bodies of these ticks expand greatly. This massive increase in body volume is accommodated by an almost simultaneous growth of the cuticle.

SANDWICH BAY: A SEASIDE SANCTUARY

The Sandwich Bay area–known to many people as a perfect place for swimming, sunning and picnicking –is also a haven for a truly spectacular range of wild flowers (some of them extremely rare), and a gathering place for hundreds of waders and wildfowl.

As it exists today, the Sandwich Bay area consists largely of unspoiled duneland which, since pre-Roman times, has slowly been displacing the sea and growing further out into the Bay. This aggregation of land has been created by two agencies: firstly, the carrying and deposition of silt at its mouth by the River Stour, and secondly the carrying of sand and shingle by tidal currents north of the town of Deal, to be deposited in the Bay area. Over the centuries since the Romans departed, the land has been built up on the eastern side of the ancient port of Sandwich, so that today it lies more than 2½km (1½ miles) inland from the nearest point of the shore.

Centuries ago much of the newly formed dune area stabilised and became agricultural land, over which the great mound of the Roman fort of Richborough Castle towers to this day. But to the east of the main Thanet to Sandwich road (A256) a strip of land more than 1½km (1 mile) wide has remained almost untouched by agriculture. Its escape from agricultural 'improvement' is due to the fact that most of the land was purchased for use as golf links, and the land not so utilised was only suitable for grazing by cattle.

The Royal St George's and Prince's Golf Courses, together with the Sandwich Bay Estate, are the most interesting areas for the botanist, while the grazing land lying between Prince's Links and the River Stour is now a nature reserve of interest to botanists, or-

Above: The sand dunes lining the seashore of Sandwich Bay are crowned with a forest of tall marram grasses which feed and shelter a host of molluscs, spiders and beetles and, later in the year, provide a haven for bird life.

Right: Among the prickly grey-green clumps of sea holly–it is the dominant plant along Sandwich Bay's shoreline–are patches of the most attractive pink-flowered, pea-like restharrow. It can be seen in flower from June to September.

Left: A large flock of knot, gathered on the low-tide shallows of the Bay to feed, takes to the wing. These and many other wading birds and wildfowl can be seen in Sandwich Bay, especially during peak migration times in spring and autumn. A pair of binoculars is almost essential if you want to watch these shy seabirds.

Left: In a year when orchids are abundant, you can see as many as half a dozen flowering spikes of one of our rarest plants–the strange and beautiful lizard orchid–growing by the roadsides leading to the Bay, and up to 50 or more scattered over the adjacent areas of coarse grass. Their numbers are variable, however, and in a 'bad' year perhaps only two or three plants may be found. This unpredictability is due to the long germination and growing period of orchid seeds, which may need from six to nine years of underground development before the first green leaf appears above the surface.

nithologists and other scientists. This nature reserve is administered by the Kent Trust for Nature Conservation and the RSPB.

Wild flower wealth During the summer many people pass through the toll gate leading to the Sandwich Bay Estate, with the sole intention of swimming and sunning themselves on the dunes by the shore, or perhaps enjoying a picnic. But to anyone with an interest in wildlife, the day is enriched a hundredfold by the profusion and beauty of the wild flowers, insects and birds to be seen on all sides–even by the roadside.

Among the plants to be seen along the footpaths and in the rough grass are the lizard orchid, the rare clove-scented broomrape (which is parasitic on the roots of the bedstraw family), the bright blue viper's bugloss and the pyramidal orchid. In wetter areas of the dune slacks, sometimes growing among tall stems of common reed, marsh orchids can be seen in profusion. These handsome plants, with their large rosy-purple flower heads, make a wonderful splash of colour during the month of June, and are very attractive to insects, particularly the brilliantly coloured burnet moth. A month later, when the fertile flowers have withered and given way to the ripe brown seed pods, the same dune slacks bloom again with the starry flowers of the marsh helleborine and buzz with the humming hordes of insects searching for pollen and nectar.

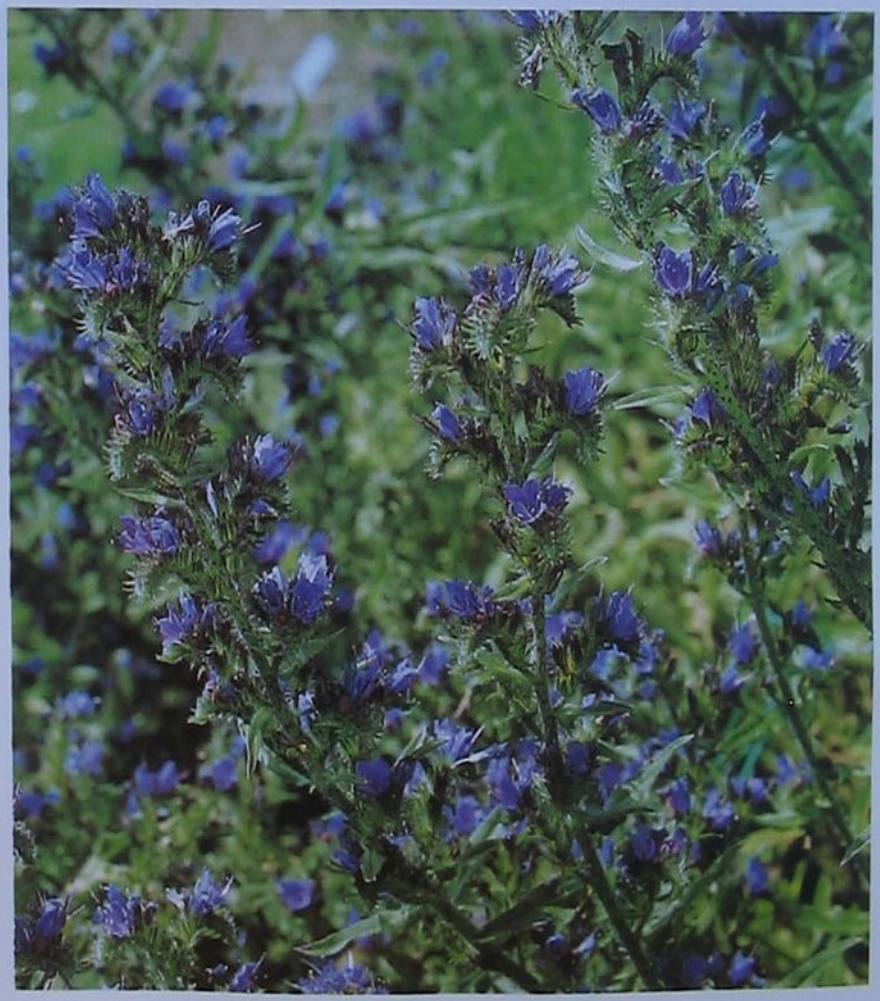
Moving up from the damp slacks to the intervening dry and grassy sandy ridges, you can find a host of wild plants, among them two outstanding species which have escaped from cultivation and are now firmly established. These are the evening primrose, whose red buds open up into bright yellow poppy-like flowers late in the afternoon, and asparagus, whose delicate fronds seem too frail to stand up to the strong, salt-laden winds that often blow in off the sea. Yet they survive such windburns better than many of the truly native plants.

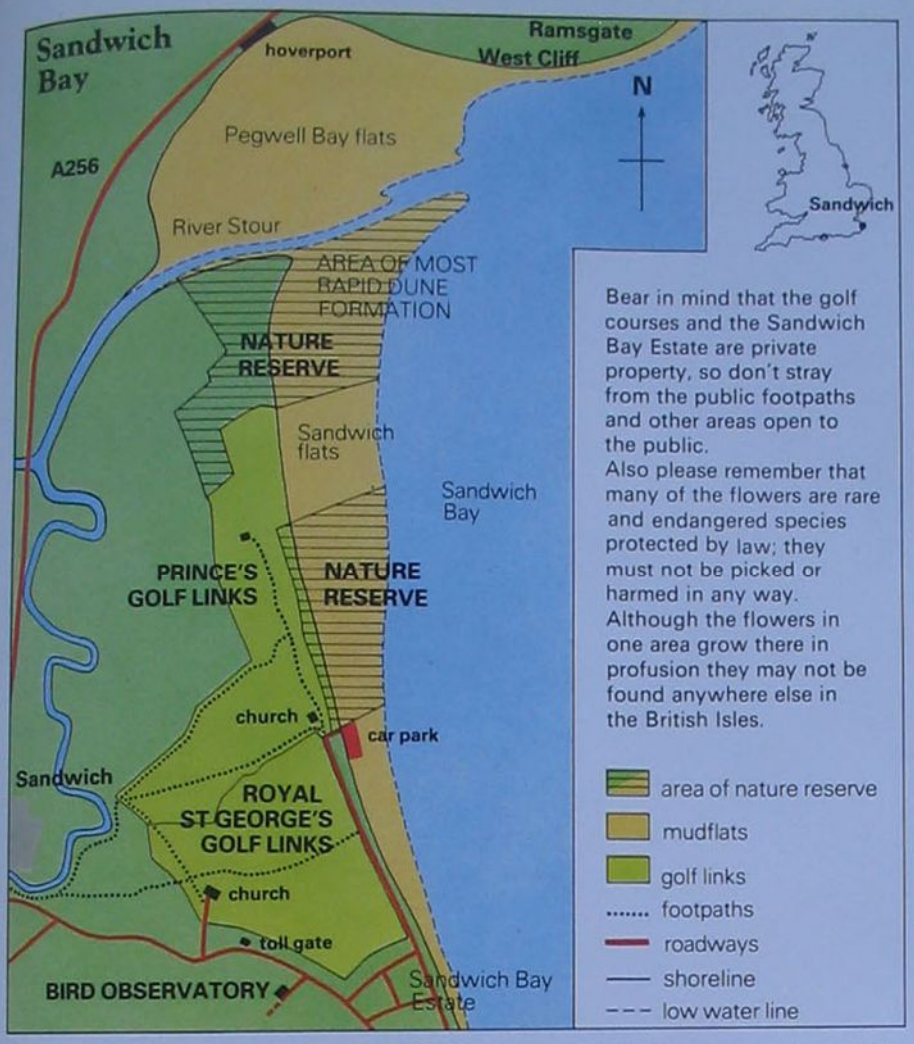
In the same areas and at the same time of year (June to August) the shrublike, rounded profile of houndstongue can be seen, with many purplish flowers on the tips of the branches. Where the grass cover is less dense (in the region of a bunker, for instance) the large pale pink trumpets of sea convolvulus hug the ground as they turn their faces to the sun, their trailing stems sprawling on the sand and holding up the small kidney-shaped leaves.

On the golf course Even on the well mown fairways of the golf course, where one would imagine flowering plants would have little chance of coming into bloom, there are interesting flowers to be seen. As early as February-March the pretty pink starry blooms of dune stork's-bill shine out from among the short grass blades, and by April the tiny, bright blue flowers of the early forget-me-not peep out among the daisies. A little later the brilliant yellow flowers of biting stonecrop can be seen wherever the grass is short or sparse, accompanied in places by the white blooms of the closely related English stonecrop.

Also surviving well in these situations are various members of the pea family, of which

Below: In addition to the stands of orchids found among the grass at Sandwich Bay, you may also see tall clumps of the bright blue viper's bugloss–a plant that is in flower from May to September. The flower buds start by being pink in colour, but become a vivid blue when fully open.





the red and yellow flowers of bird's-foot trefoil are familiar to everyone. This group of plants is also parasitised by one of the broomrape species, the lesser broomrape, and in late June and July the fingerlike stems of this plant can be seen thrusting upwards, sometimes in little groups, looking rather like sticks of pink asparagus.

The seashore The dominant plant of the seashore is sea holly, its prickly clumps sometimes interspersed with patches of rest-harrow. The dunes themselves are covered with tall, waving marram grasses–the first colonizers and stabilizers of the shifting sand.

The fore-dune area, being the part most exposed to battering by wind and sea, has a rather unstable plant population. You can expect to find sea couch grass and marram grasses and they may be accompanied by scrubby little plants such as annual sea-blite and sea saltwort. Hugging the sand near the grasses are clumps (sometimes quite extensive) of little greyish-green plants with oval, fleshy leaves and tiny white five-petalled flowers. These are sea sandwort plants, resistant to both salt and dehydration by wind. In the same area grows an equally tough and fleshy plant, though considerably larger and more shrub-like in appearance and bearing handsome four-petalled pink flowers from June to August. This is sea rocket, which is sometimes found growing in colonies of several clumps just above the level of the highest spring tides.

A little further inshore grow sea plantain and buck's horn plantain, in company with the fleshy silvery-green sea spurge. And most silvery of all, growing in the saltmarshes and up the muddy creeks, masses of sea purslane flourish in dense clumps. In late summer this makes a lovely background for the bluish-purple flowers of sea lavender, elegantly arranged in a curving spike at the tip of a tall slim stem. Less spectacular, but equally interesting, are the little tufty, branching plants growing in and often submerged by the muddy sea water. This fleshy, salt-loving species is perennial glasswort; the plants have a strong reddish tinge and produce tiny flowers which must be seen through a magnifying glass to be appreciated. They are one of the few species of land plants which have adapted to a salt-water habitat.

Seashore birds The seashore itself is the area where most birds will be seen, whatever season of the year it may be. Most of the birds are extremely shy and unapproachable. It is

Right: The rare and beautiful clove-scented broomrape can be found on the golf course roughs. This parasitic plant has three colour forms–either pale cream, pale rose or puce. It grows no leaves and taps the roots of the bedstraw family for sustenance. It usually flowers in June.

Below: Keep an eye open for the ringed plover on the shores of Sandwich Bay. Here the bird is guarding some well-camouflaged eggs.

Above: The wealth of wild flowers in Sandwich Bay attracts an enormous variety of insects–including this six-spot burnet moth.

Below: Sea holly is found everywhere on the shore.

best to sit or lie on the edge of the dunes by the shore, watching with binoculars and waiting for the birds to come closer, rather than to try to approach them. During peak migration periods great flocks of waders may be seen, commonly of oystercatchers, godwits, knot, dunlin, curlew, sanderling and many others. Various species of gulls and terns fly overhead, or come down to feed in company with grey and golden plover, ringed plover, carrion crows and even the occasional rook. Out on the mudflats the goose-like shelduck feed, sometimes with wigeon or teal.

Inshore, the fore-dune area is a rich source of food and shelter during the winter months for wandering flocks of finches and larks. Snow buntings frequently overwinter in the area of the Nature Reserve, in company with linnets, greenfinches, twites and reed buntings. In hard weather thrushes and blackbirds find snails and other creatures among the marram tussocks when the remainder of the countryside is covered with impenetrable snow. Small flocks of shore larks, too, wander up and down the coastline, along with skylarks and meadow pipits.

In the middle dune area, with its more stable vegetation of coarse meadow grasses and dune slacks with dense clumps of the rare sharp sea rush, you may flush out a pair of ground-roosting short-eared owls that spring into the air and then appear to float away with long, lazy wingbeats. Equally unexpectedly, from the blind side of a clump of rushes or a bed of reeds, a large bird may appear, gliding close to the ground on long uptilted wings. A white ring round the root of the tail proclaims it to be a hen harrier (one of our rarer raptors), which has taken to wintering and hunting in the lower Stour valley in appreciable numbers over the last decade–as many as 30 may be seen in some peak years. The presence of these hunters implies the existence of a population of voles and mice in sufficient numbers to support the raptors for four or five winter months and still to survive as a viable rodent population.

The Bird Observatory In addition to the golf links and Nature Reserve, there is also the Bird Observatory, which has been in operation at Sandwich Bay for many years. Here birds have been trapped and ringed, weighed and recorded, then finally released to travel onward on migration to their summer or winter destinations. Slowly, over the years of patient recordings from this and many other stations like it all round the world, we have learned where at least some of these birds go, and also that many come back again to the same spot year after year.

The Nature Reserve's Warden has his headquarters at the Bird Observatory during the summer months. Here a very limited amount of accommodation (of a rather spartan kind) is available. All enquiries and requests for visits to see the Nature Reserve should be addressed to the KTNC Reserve Warden, Sandwich Bay Bird Observatory, Old Downs Farm, Sandwich Bay, Kent. No such request is needed, however, by anyone wishing to look at the wild flowers growing on the golf courses and around the Estate. Any arrangements for staying at the Observatory should be made well in advance.

Above: A rowan tree in full fruit on Dartmoor. Its round, bright red fruits look like berries, but they are not. In fact, their structure is very similar to that of an apple.

FLESHY FRUITS: THEIR FORM AND FUNCTION

All flowering plants bear fruits but those that come to mind most readily are the ones we eat, such as apples, plums and blackberries. These fleshy fruits are a special adaptation by plants to tempt both man and animals alike into eating them and so dispersing the seeds inside.

Below: Cranberry fruits are true berries because they consist of seeds embedded in a fleshy structure developed from the ovary wall inside the flower. The closely related bilberry also bears true berries.

To most people the word 'fruit' conjures up the image of a succulent fruit–an apple or a peach, or perhaps something more exotic like a mango or a pineapple. But to a botanist the word has a rather different and more precise meaning. Many of the 'fruits' of the layman are not fruits at all–for example the fleshy leaf stalks of rhubarb are not, strictly speaking, a fruit.

Fertilisation and fruits In the narrow botanical definition, a fruit is a structure formed from the wall of the ovary and containing the matured, usually fertilised ovules–the seeds. All flowering plants have fruits. When a flower is pollinated, pollen grains land on the flower's stigma and each

Above: The attractive red fruits (actually berries) of the misnamed strawberry tree, a member of the same family as cranberry.

Below: The true strawberry bears its fruits in the form of pips embedded on the surface of a fleshy red mass–the receptacle.

produces a tube which tunnels through the style and ovary wall. The ovary contains one or more ovules, each containing a female sex cell. When the pollen-tube reaches the ovule a nucleus from the pollen grain, acting as a male sex cell, fertilises the female sex cell.

Once fertilisation has taken place the ovules mature to form seeds, while the ovary wall develops into the fruit. In some plants the ovary wall swells up to become succulent, forming what is often called a fleshy fruit.

Why fleshy? Most fleshy fruits represent a particular adaptation to ensure that their seeds are dispersed. A fleshy fruit is there to be eaten by an animal–including man. Even fruits that are poisonous to us are usually edible to some species. For example, deadly nightshade is eagerly eaten by pheasants with no apparent harmful effects.

Once eaten, the fleshy part of the fruit is digested but the seeds have a resistant coat that protects them against digestive juices until they are voided. Because of the time lapse, this is likely to happen some distance from the parent plant, so the seeds will have been successfully dispersed and, moreover, with a ready supply of fertiliser.

Some species of plant have become so well adapted to this mechanism of seed dispersal that the seeds will not germinate under normal conditions until they have been acted upon by enzymes in the digestive tract.

Fleshy fruits come in all sorts of different shapes, sizes and colours, and they can be divided into groups according to which parts of the original flower form the various parts of the fruit.

Berries These are fruits in which the entire wall of the ovary becomes more or less fleshy. Within this flesh are embedded one or more seeds. Among the most familiar berries are those belonging to species of the nightshade family, such as deadly nightshade and black nightshade–both of which have black berries –and the red-fruited woody nightshade. The tomato also belongs to the same family; in this case what we usually regard as vegetables are actually fruits–berries.

Among the more exotic fruits eaten in Britain, oranges, bananas and marrows are all berries, though they seem very different. Our own native member of the marrow family, white bryony, has globular red berries which look quite unlike the small, gherkin-like fruits of the squirting cucumber, an introduced member of the same family. This species is naturalised in southern England, spreading itself vigorously by means of its explosive fruits. When ripe, the slightest knock sends a stream of watery, seed-laden juice several metres.

The white-berried mistletoe has sticky seeds that adhere to the beak of a bird as it feeds on the fruits. In the bird's attempts to remove the irritating seeds, it rubs its beak on the branch of a tree, thus depositing the source of its annoyance in crevices–the ideal spot for the seeds of this parasitic plant to germinate and grow.

Stony drupes In the second group of fleshy fruits the inner part of the fruit wall becomes hard and stone-like, encasing a single seed, and the outer part of the wall becomes fleshy. The whole structure is known as a drupe. The most familiar examples of drupes are provided by members of the genus *Prunus*, such as plums and cherries. Wild British species

include the gean, bird cherry and sloe, or blackthorn. The bullace is a naturalised member of this genus with fruits similar to sloes, though larger; the damson is probably a cultivated form of the bullace. Also in this group are greengages, which belong to the same species as plums.

If you look at the stone of a fruit in the plum group you can sometimes tell which species it came from. The stone of an almond is smooth except for numerous small pits. (What most people know as an almond nut is really the stone or the seed inside this stone.) The globular stone of a bird cherry, on the other hand, is covered with short curved ridges, while a sloe stone is covered with irregular bumps. A plum stone is elongated and slightly rough, with grooves along one edge.

Most people think of the elder's black fruits as being berries, but they are in fact drupes. The raspberry is also not a true berry. It is a compound fruit, consisting of a number of small round segments, each of which is a drupe containing a stone (the pip) just like that in a cherry. The thick stalk around which the drupes are arranged is derived from the receptacle of the flower. In the same genus, *Rubus*, is the blackberry, which may have more than 60 drupes to each berry.

False fruits One of the most unusual fruits in the British flora is that of the wild strawberry, which is not technically a fruit at all. The fleshy succulent part is the enlarged receptacle at the base of the flower, so the whole structure is known as a false fruit. The actual fruits are the small yellowish pips scattered over the surface. They correspond to the individual drupes of a blackberry, both plants belonging to the same family, the rose family. A plant very closely related to the wild strawberry is the barren strawberry, in the genus *Potentilla*. However, this plant lacks the fleshy receptacle and has just a head of tiny dry fruits.

Crab apples also belong to the rose family but in this case the inner part of the apple (the core) corresponds to the true fruit while the outer part is formed from the receptacle. The fruits of other members of the rose family are constructed in the same way, including the fruits of roses, known as hips, hawthorn fruits, which are known as haws, and rowan 'berries', which are not true berries.

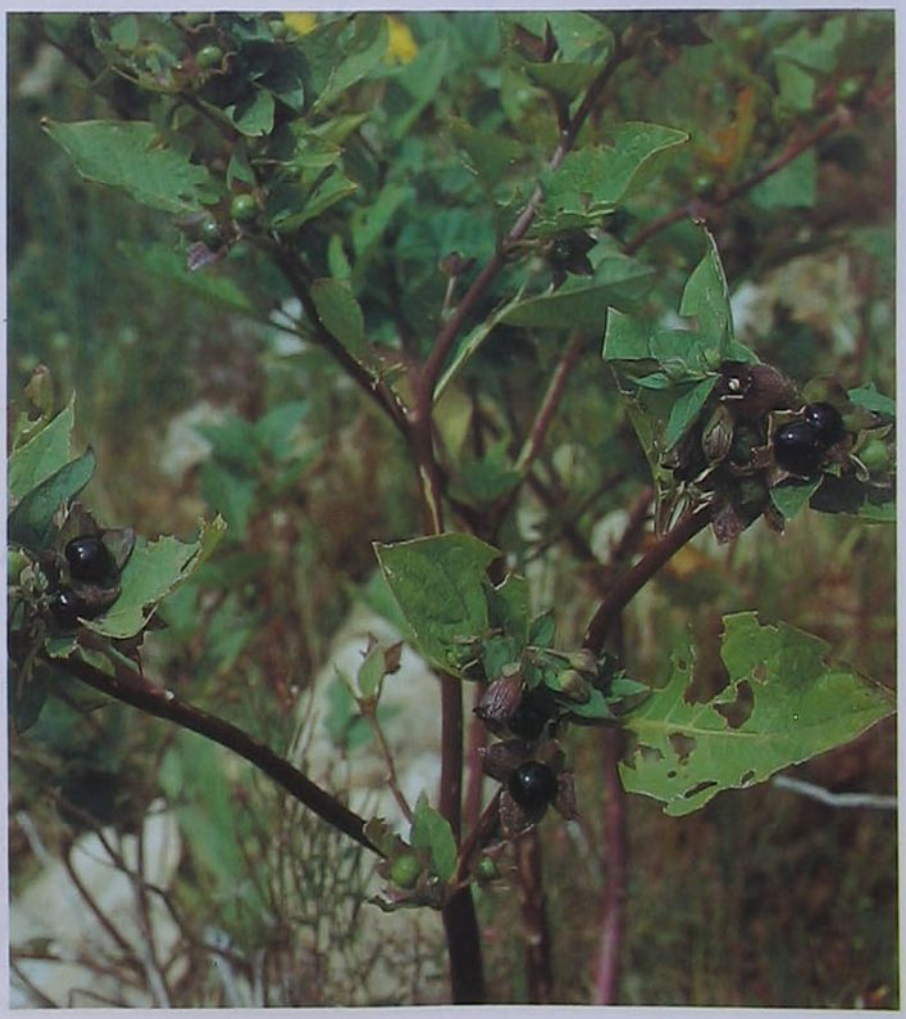
Other false fruits may develop from different parts of the flower. In the mulberry the female flowers are borne in clusters resembling catkins. After fertilisation the sepals of each flower enlarge to form a small berry-like false fruit. These are borne in clusters in the same arrangement as the flowers, so the effect is of a compound fruit looking rather like a blackberry. A very familiar false fruit is the pineapple, which develops from the stalk and bracts of the flower head.

Fruit impersonators A few plants bear structures that seem to be fruits but are not. The fleshy red arils of a yew tree, for example, are not fruits because they do not develop from flowers. Yew trees are conifers, not flowering plants, and the arils are equivalent to the individual scales found on the cone of a pine or fir tree.

Some fleshy, brightly coloured structures that resemble fruits are actually seeds, for example, the red seeds of the gladdon, or stinking iris. The fruit of this plant is the whole capsule containing the seeds.

Above: An unusual relative of the familiar black-fruited elder is the alpine elder, which bears red fruits. Native to the Continent, this shrub is widely naturalised in southern Scotland.

Below: Ripening berries of the deadly nightshade.



EDIBLE CRABS: SEA-BED MIGRANTS

The edible crab is one of the largest marine invertebrates found in Europe. This crustacean is a relative of the lobster, and around British coasts the two species often inhabit the same areas of rocky ground, where they compete for food and shelter.

The edible crab has a reputation as a scavenger, but this is misleading, for it also feeds on living prey such as small fishes and marine worms. Shellfish, such as mussels and barnacles, are easily crushed in its powerful claws. It is extremely voracious, and has a keen sense of smell which helps it to find its prey on the sea bottom.

Moulting the shell Crabs, like all crustaceans, are covered with a hard, rigid shell known as an exoskeleton. In order to grow, crabs have to cast these outer shells, made of calcified chitin. This is known as moulting, or ecdysis. During the first few years of life, when growth is rapid, a crab moults several times a year, but by the time it becomes sexually mature moulting may occur only once a year, or even less frequently.

Immediately after moulting, the crab has a soft shell. It absorbs water and swells, increasing in size across the back by as much as 20% or 30% in one moult. On average, an 8cm (3½in) male grows to 11.5cm (4½in) in one moult, and 14.5cm (5¾in) in the next. After a moult, the new shell slowly hardens and the crab's body ceases to increase in size, until after the next moult.

Above: An edible crab on the shore. This species (*Cancer pagurus*) forms an important source of food for man, and in 1982 the shellfishermen of Britain recorded a total catch of over 8000 tonnes of crabs, valued at £4 million.

Summer mating The sex of a crab can be easily determined. The female or hen crab has a broad abdomen (unlike lobsters, prawns and shrimps, a crab has an abdomen that is folded flat under the body). In contrast, the male or cock crab has a narrow abdomen, which fits tightly to the body. The claws of the male are also larger than those of a female of the same body size.

Mating occurs in inshore waters during the summer, immediately after the female crab has moulted and while she is in the soft-shelled condition. Prior to the moult, and for a period of up to a fortnight afterwards, the male stays close to the female, being attracted to her by a scent or pheromone, which she gives off during breeding time.

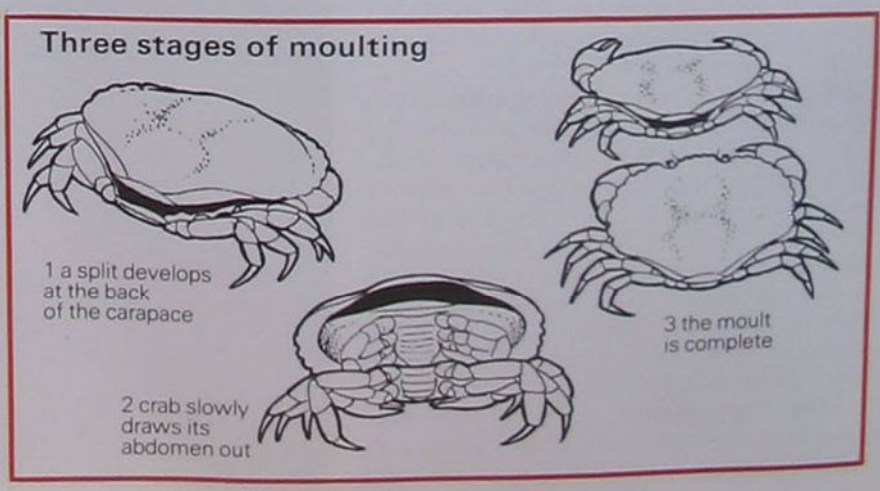
Immediately the female has cast her shell, mating takes place, and the male's sperms are introduced into the female's two sperm sacs. One supply of sperm may fertilise two or more batches of eggs, and so may be sufficient for at least the following year.

The eggs remain attached to the 'swimmerets' on the abdomen of the mother for about seven months. A crab with eggs is sometimes called a 'berried crab', and the number of eggs varies from half a million on a 12.5cm (5in) crab to three million on an 18cm (7in) crab.

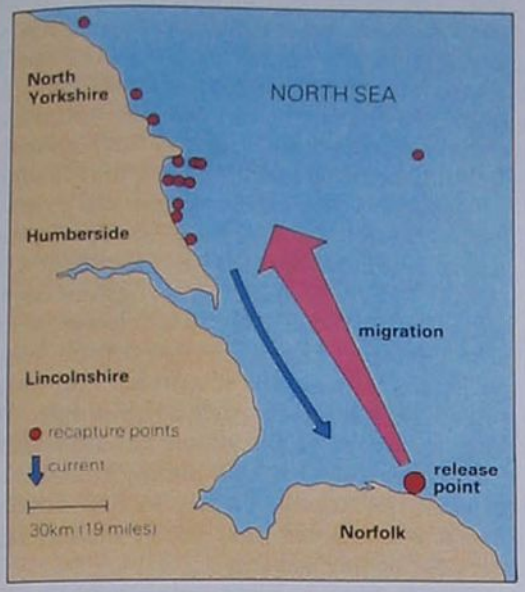
Hatching and larvae Crabs usually select a soft sea-bed for spawning (extruding the eggs), often in deep water. This occurs during November or December. In the spring and summer following spawning, the 'berried' females move inshore, where the eggs hatch. Hatching times vary for the different stocks of crabs around our coasts, but the main periods are all between May and September.

The young larval crabs which emerge from the eggs have a shrimp-like appearance, and live among the free-floating plankton in the surface water layers for about a month. This period is a dispersal phase, because the larvae, which are extremely small (less than 2mm long), can be transported considerable distances by water movements from where they first hatched.

Crab migrations Investigations in the 1960s

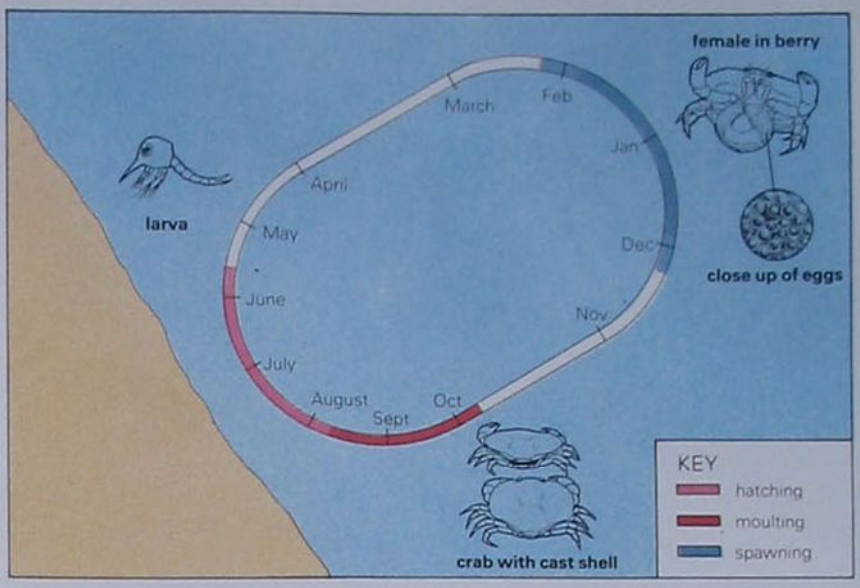


The sea-bed walk of the edible crab



Long-distance migrations

A total of 1228 crabs were released in the Norfolk crab fisheries, known to be a good habitat for the animal. This map shows the 13 most distant recapture sites, corresponding to the longest migrations recorded in the Norfolk experiment (many other crabs were recaptured nearer the release point). This provided experimental evidence of the actual distance of the migration for the first time.



A circuitous journey

Moulting and mating take place during the autumn, when the crabs are close inshore. The female then migrates to deeper waters and softer sea-beds, since these provide a more suitable environment for the process of spawning, or extruding the eggs. With the eggs placed on her swimmerets (underneath her abdomen) she returns inshore, to arrive in time for hatching, which takes place in summer. While the young then drift back in the sea current to where the cycle began, the mother may possibly head for the deeper water to spawn a second time; it is possible that the more distant recaptures are of females that have been out to sea twice or more often, returning to a more northerly point each time.

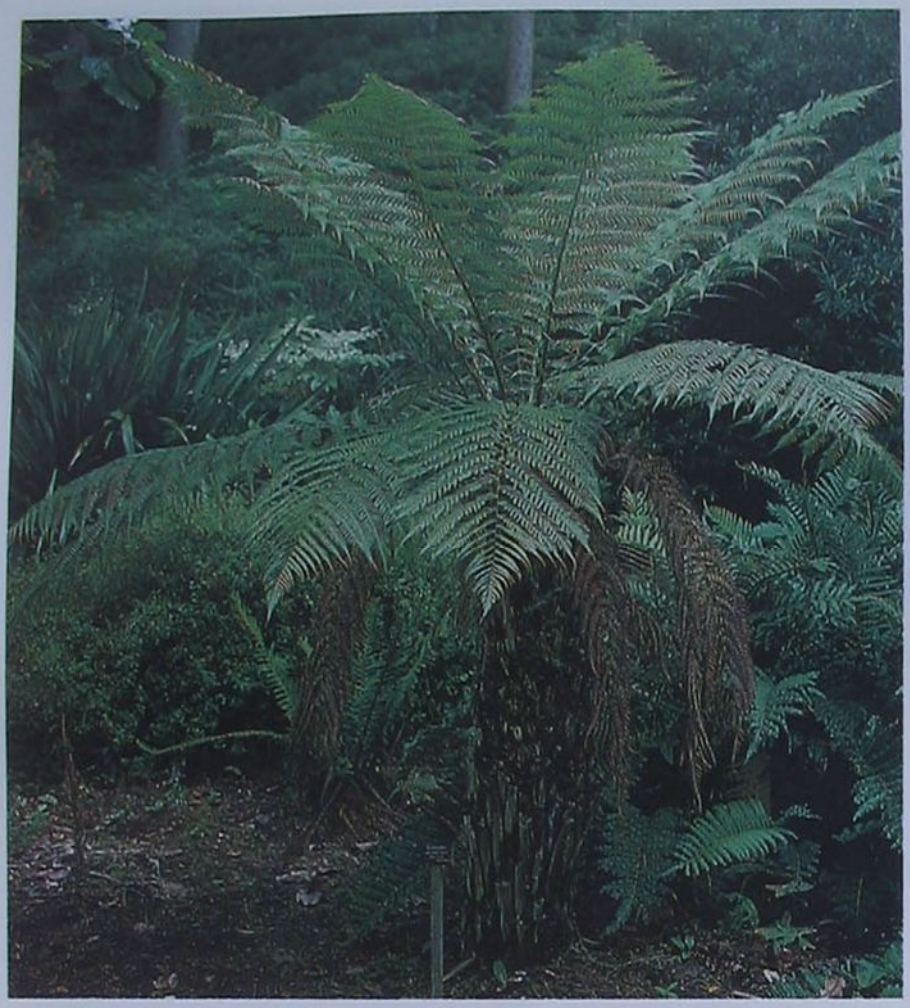
and 1970s have revealed some interesting facts about the migration of crabs. A small tag, which is not lost when the crab casts its shell, was attached to a large number of crabs of both sexes. Each tag was numbered, and a record was kept of the size, sex and shell condition of each crab marked in this way. The crabs were then released in the sea. Fishermen who caught tagged crabs were rewarded if they returned the crabs, providing information on the date and place of recapture.

Some of the crabs, for example, were released on the Yorkshire coast. A total of 135 females were recaptured, and of these over 40% were found to have moved distances of 32km (20 miles) and over. Nearly all of these migrations were in a northerly direction, the crabs being caught in North Yorkshire, Durham, Northumberland or Scotland. The longest distance moved was by a female released near Flamborough Head, which was recaptured off Berwick (Northumberland) 16 months later, having moved 260km (163 miles). For male crabs, the results were different, and only 51 of those recaptured had moved distances of 32km (20 miles) or more.

The migration of the females can be seen to compensate for the effects of sea currents that move in the opposite direction. The mother moves northwards from a suitable habitat for crabs, so that the larvae will drift back to the same area when she has hatched them. She thus ensures that, despite the sea current, as many as possible of her young will have a suitable habitat for their survival.

Crab fisheries In England there are three main crabbing areas–the coasts of Northumberland and Yorkshire, the south-west coast of Devon and Cornwall, and the small but productive fishery off Norfolk, based on Sheringham and Cromer. Crabs are also plentiful on all coasts of Scotland, with traditional fisheries along the east coast. However, Shetland and Orkney now account for over 30% of Scottish crab landings, and catches from the Western Islands are increasing as stocks of crab, previously unexploited, are now being fished.

Below: A sizeable mature crab on a bed of seaweed. In Britain, both national and local regulations govern the size and condition of crabs that may be landed and sold. The national minimum landing size is 11.5cm (4½in) across the broadest part of the crab's back. In some areas, local regulations have raised the minimum size to 12.7cm (5in). In addition, national regulations prohibit the landing of both 'berried' and soft-shelled crabs.



ALIEN FERNS IN OUR COUNTRYSIDE

Above: The tree fern, *Dicksonia antarctica*. The tall trunk of these ferns is quite different from the trunks of trees, for it consists mainly of roots. The true stem of a tree fern, which supports the fronds, is a slender core inside this sheath.

Below: The mosquito fern (*Azolla filiculoides*) from tropical America can be found growing in British ponds, drainage ditches and slow-flowing streams, often blanketing large areas.

Some of the most attractive and unusual ferns found in our countryside are not native species but exotics that have escaped from gardens.

Compared with the number of flowering plants that are native to the British Isles, relatively few ferns and allied plants fall into the same category–only about 60 species in all. Because of this, alien ferns are, with a little practice, easily spotted in our countryside.

Most exotic ferns were introduced to Britain for ornamental purposes–to be cultivated in gardens and greenhouses. Some, however, escaped to the wild, where they succeeded in establishing themselves and becoming naturalised. These are the alien ferns.

Tree ferns from Australia The most spectacular alien fern is the tree fern, so-called because it has a tall upright stem, about 2m (6ft) tall, supporting a whorl of fronds, so that the whole plant looks something like a palm tree. The species of tree fern that has become naturalised in Britain is *Dicksonia antarctica*, a native of the cooler parts of Australasia, where it can reach a height of more than 15m (50ft). In Britain, it has become naturalised only in south-west England and southern Ireland, both places with mild winter climates.

The fronds unfurl in spring and grow to become over 1m (3ft) long–though in their native lands they can reach a length of 4.5m (15ft). They are dark glossy green on the upper surface and paler on the lower, with a stiff texture. The undersides bear round patches. These are the sori which bear spore-producing structures called sporangia. The huge fronds die in the winter but are retained for some time by the plant, probably to protect the young, tightly curled croziers, which will become next year's foliage, from the cold winter weather.

Ostrich fern The handsome ostrich fern was first introduced to Britain in 1760. It is native to northern parts of North America, northern Asia and parts of Europe, again mainly the north. In this country it can be seen growing in the wild on the banks of streams and waterfalls, and in moist meadows. It tolerates both sunny and shady habitats.

Its name comes from the resemblance of its tall fronds to ostrich feathers. It bears two types of frond: sterile and fertile. The sterile ones can reach a length of 1.5m (5ft) but are more usually about 1m (3ft) long. Each frond curves gracefully outwards from the top of a stout trunk-like structure in a spectacular shuttlecock arrangement. The fertile fronds are shorter than the sterile ones, and only a few are produced at any one time by a plant. They appear in late summer and mature in the autumn, the undersides bearing masses of round sori that join up together and cover the pinnules (the 'leaflets'). This fern can also reproduce by means of creeping underground shoots.

Sensitive to the touch Another introduced fern with separate fertile and sterile fronds is the sensitive fern, a species native to North America, where it is common, and northern

Asia. It was grown in the Oxford Botanic Garden as early as 1699 and has been recorded as naturalised in the British Isles since about 1840.

It is called the sensitive fern because its thin, delicate sterile fronds are said to wither if you run them once or twice through your hands. They certainly wilt very rapidly when picked. The sterile fronds are deciduous and die quickly after the first frost, but the fertile fronds, which are smaller (about 50cm/20in tall), remain throughout the winter, their colour changing from green to brown as the sori mature. The spores are released in the spring. Like the ostrich fern, the sensitive fern can also spread by means of underground shoots and it sometimes forms large colonies in this way.

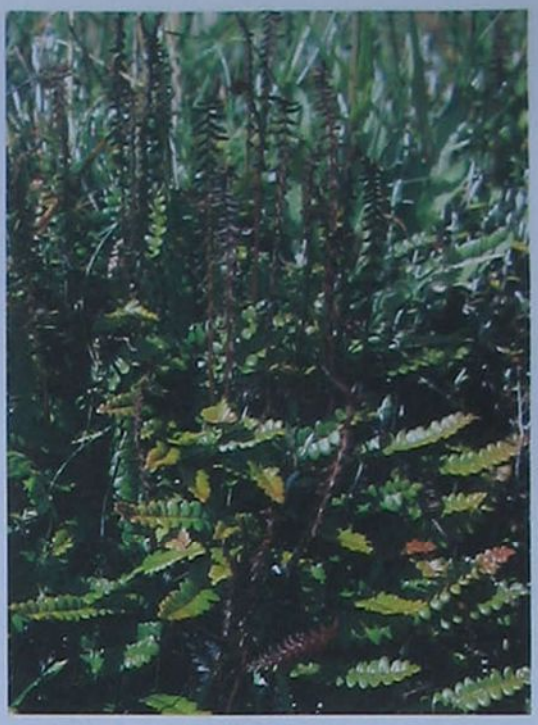
Another species from northern Asia that has managed to establish itself here is *Cyrtomium falcatum*. Related to our own native shield ferns, though not closely, its fronds grow from a central stem, arching gracefully outwards. Provided the winter is not too severe, this fern remains evergreen throughout the year.

Coal tip survivor Two European species belonging to the genus *Pteris* are found naturalised in Britain. *Pteris vittata*, from the Mediterranean region, is able to survive the British climate only because of its curious and very limited habitat here. In the Forest of Dean there is a coal tip (which also has many fossilised ferns) which has been smouldering for some years, thus creating a micro-climate warm enough for this fern to flourish. Its fronds are about 50cm (20in) long, with long narrow pinnae ('leaflets') well spaced along the central stalk, the rachis.

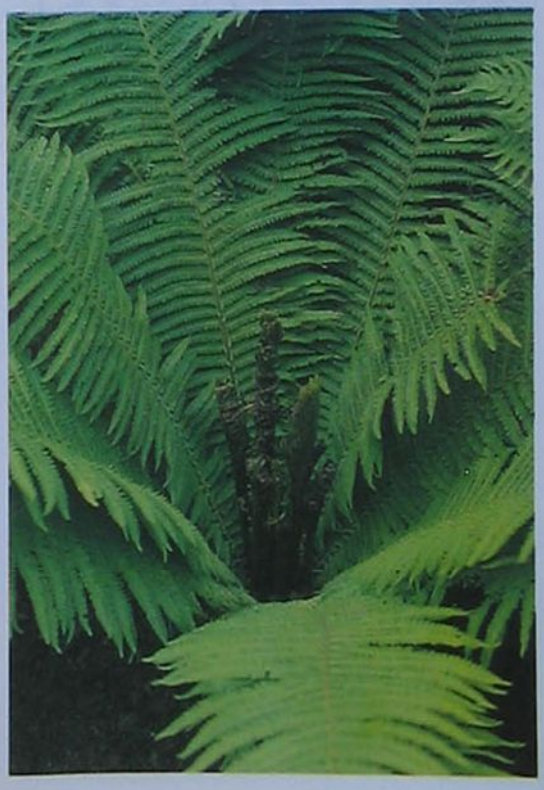
Another naturalised species in this genus, *Pteris cretica*, from southern Europe, Africa, Asia and the Americas, is a common house plant in this country. It grows to a height of about 50cm (20in).

Mosquito fern Perhaps the most curious of all the alien ferns found in Britain is the mosquito fern, an aquatic plant looking, at first glance, like a floating liverwort. Each tiny plant is only 1-2cm ($\frac{1}{2}$-1in) across and consists of a branched stem with roots hanging down into the water and a series of minute leaves that overlap each other in the same way as do the tiles on a roof. Each leaf consists of an upper lobe lying on the surface of the water and a lower submerged lobe. The upper lobe contains a chamber occupied by strands of blue-green algae, which exist there in a symbiotic relationship with the fern. The plants are usually green but may be reddish, especially in the autumn.

As more and more exotic ferns are introduced to Britain for our homes and gardens, so the chance of one of them escaping to the wild and becoming naturalised here increases. In the future, therefore, we can look forward to even more alien ferns adding variety to our countryside.



Right: Two relatives of our native hard fern (*Blechnum spicant*) have become naturalised in Britain. The one shown here is *Blechnum penna-marina*, a native of temperate zones in the southern hemisphere. It is a smaller plant than the hard fern. Like other members of this genus, the fronds are dimorphic, ie the sterile and fertile fronds look different. The sterile fronds have round, glossy, leathery-looking pinnae and grow to a length of 20cm (8in). The fertile pinnae are thinner, more upright and longer–about 30cm (1ft) long. Their pinnae are much narrower than those on the sterile fronds and are coloured brown from the presence of large numbers of sori.



Above: The other relative of the hard fern naturalised in Britain is *Blechnum chilense*, which comes from the southern tip of South America and is also native to the Falkland Islands. This plant is one of the most attractive species in the genus, the fronds growing to a length of about 1m (3ft) and being a deep glossy green, with a leathery texture.

Right: The ostrich fern (*Matteucia struthiopteris*) is one of the largest alien ferns to be seen in the British countryside, its sterile green fronds sometimes reaching a length of 1.5m (5ft). In the centre of the plant can be seen the shorter fertile fronds.

INSECTS IN THE GARDEN

Look around your garden and you will be amazed by the abundance of insects. Some are a positive advantage, pollinating the flowers, but others can be serious pests.

Above: The summer generation of small tortoiseshells can be seen feeding on lavender in the garden.

Below: The honey bee is one of the earlier insects in the garden, putting in an appearance as soon as the days warm up.

Most kinds of insects can be found in gardens at some time or other. Some are merely casual visitors from the surrounding countryside, but many are actually resident. Northern gardens support fewer species than southern gardens, and new gardens also have fewer species than established ones–many insects cannot take up residence until the garden plant life is reasonably mature.

Spring Some insects are present all year round. Bluebottles and various other flies, for example, can be seen basking on sunny walls even in the middle of winter. Most species have definite seasons, however, and insect populations change markedly between spring and autumn.

Among the first to stir in spring are those insects that hibernate as adults. Brimstone, peacock and small tortoiseshell butterflies fly on warm days even in February, seeking

The ants' wedding

Ants are extremely common in the garden, but they are generally unobtrusive for much of the year. The commonest species is the black *Lasius niger* which feeds on a variety of small insects and also 'milks' aphids for honeydew. This species breeds under paths and rockery stones, and the nests 'explode' in July or August when thousands of winged ants take to the air for their mating flight. The winged ants are males and new queens (right) which have been nurtured by the workers for several weeks. When the weather conditions are right–reasonably still, warm and humid–the workers open the nests and allow the winged forms out for their mid-air matings. All the nests in one area tend to erupt at the same time, thus encouraging inter-marriage between the different colonies.

The great majority of the ants fall victim to swallows and other birds, but of those which return to the ground, the males soon die while the queens break off their wings and search for suitable places in which to start their new colonies.

nectar from any flowers that happen to be open, but not until the aubrietia and polyanthus come to flower later in the spring do these butterflies become particularly busy. They are soon joined by the first broods of large and small whites, which emerge from their pupae early in April.

Honey bees put in an appearance as soon as the days warm up, mingling with the droneflies on the snowdrops and crocuses. Bumble bee queens emerge from hibernation and are active as soon as the temperatures begin to rise. Several species are common in the garden, with *Bombus pratorum* being one of the earliest to appear. Other garden species of bee include *B. lapidarius*, *B. pascuorum*, *B. lucorum* and *B. hortum*. The bees all find plenty of nectar in deadnettle flowers and sallow catkins, and build up their strength in readiness for nesting.

When the aubrietia opens on the rockery the fascinating bee-fly is never far away, hovering over the plants or rising and falling like a miniature helicopter, all the time emitting a high-pitched whine.

Queen wasps, like queen bumble bees, pass the winter in hibernation, and when they wake they need a plentiful supply of energy-rich food. Nectar provides most of this, and the wasps can be seen buzzing around cotoneaster and other early flowering shrubs. If the flowers are not yet open, the wasps bite through their bases to reach the nectar. (Apple blossom is commonly damaged in this way.) When not feeding the wasps can often be seen, and even heard, scraping wood from sheds and fences; this they chew and mix with saliva to make the paper for their nests.

Above: Unwelcome visitors in the vegetable garden include the large white butterfly. The females lay their eggs on brassicas, where they hatch into caterpillars which gorge themselves on the leaves.

As you get busy in the garden, digging and weeding in readiness for spring planting, you may well uncover many ground-dwelling insects. As gardeners you can do without the root-eating leatherjackets (cranefly larvae) and wireworms (click beetle larvae), but you should look kindly on the predatory ground beetles, such as the violet ground beetle, that scuttle rapidly over the surface feeding on harmful insect larvae.

During May many garden plants become decorated with blobs of white froth known as cuckoo spit. People once thought this really was cuckoo spit as it seems to appear from nowhere at a time when cuckoos abound. It is in fact produced by the nymphs of frog hoppers which feed on the plant sap. The froth protects the nymphs from desiccation and also from predators, to a certain extent.

Summer As spring passes into summer the aphids multiply rapidly on many garden plants, exuding large quantities of honey-

Right: The aphids which you find in the garden in summer are females, all of which can give birth to several offspring in one day–no wonder populations build up so rapidly. Fortunately we have our allies to fight them. Ladybirds, like this 7-spot, and their larvae are great aphid-eaters, sometimes consuming as many as 100 individuals in a single day. Other insects which help control aphid populations are the delicate green lacewings and hoverfly larvae.

Above: Gardens, with their extremely varied mixture of foreign plant species, represent an artificial habitat, yet a surprisingly large number of insects can be found in them.

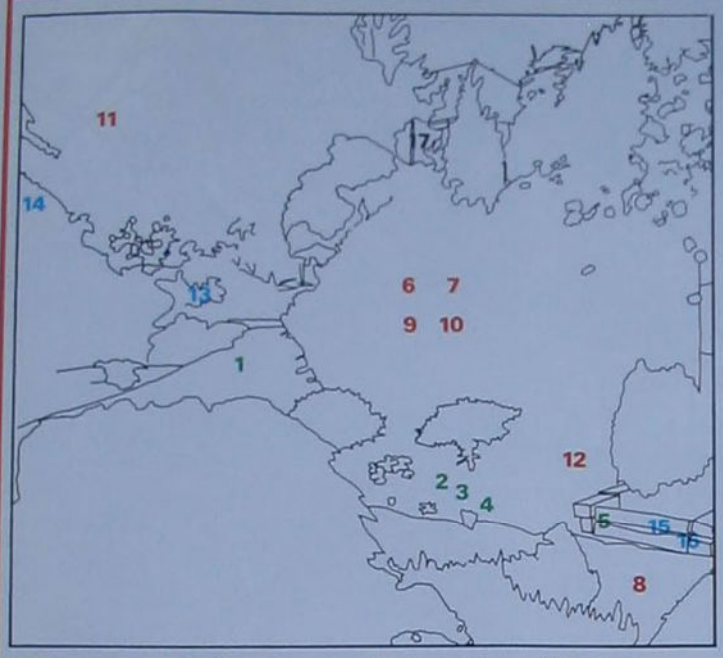
Left: Common wasps find ripe fruit particularly attractive in late summer. By then they have finished rearing their broods and the workers now spend the last few weeks of their lives gorging themselves. Half a dozen wasps can soon reduce an apple to a few pips and some pieces of skin. Other insects attracted to ripe fruit include the red admiral–which can become so drunk on the fermenting juices that you can easily catch it–and earwigs which can be found curled up asleep in crevices in the fruit.

dew, eagerly sought by ants and many other insects.

Garden insects reach a peak in high summer when every flower has its attendant hoverfly and often many other insects as well. The summer generations of small tortoiseshells, peacocks and brimstones feed on lavender and buddleia nectar, and may be joined by the wall brown and comma butterflies. The large and small whites join the throng when they are not busy laying eggs on the brassicas, together with their harmless relative, the green-veined white.

Wander around the garden at night with a torch, or better still, shine a reading lamp out of the window, and you will soon be aware of the large numbers of moths in the garden, feeding at the flowers or simply flying about in search of mates. They include the yellow underwings, whose shiny brown pupae you may well have dug up in spring, and the tiger moth and its cousins, the white and buff ermines.

Several day-flying moths also occur in the garden during the summer and autumn. Best



1-5 spring **6-12** summer **13-16** autumn **17** winter

Insect niches

1 Mining bees make mines in the lawn for the females to lay their eggs in. **2 Leatherjackets** (cranefly larvae) feed on roots in the soil. **3 Wireworms** (click beetle larvae) also occur in the soil where they feed on plant roots. **4 Violet ground beetles** scuttle over the flowerbeds looking for stones to hide under. **5 Bee-flies** bask in the sun on brickwork. **6 Aphids** occur on garden plants in very large numbers, where they exude honeydew. **7 Ladybirds** are also present on garden plants, where they feed on aphids. **8 Garden ants** emerge from cracks in the path when it is warm. **9 Hoverflies** visit garden flowers. **10 Leaf-cutter bees** occur on roses, where they cut off pieces of leaf with which to line their burrows. **11 Lackey moth** caterpillars feed on the leaves of birch trees. **12 Bumble bees** visit a number of flowers, but especially rockroses, collecting nectar. **13 Earwigs** can be found curled up in the seed capsules of columbine. **14 Green lacewings** occur on viburnum. **15 Wasps** can be seen almost anywhere in the garden, but if there is rotting fruit around they are particularly abundant. **16 Green bottle flies** like basking in the sun on stones. **17 Winter moth** males can be seen on window panes right through the months of winter.

Left: While digging up the garden in spring, you are highly likely to come across wireworms–click beetle larvae–in the soil. These worm-like grubs are the gardener's enemies since, like leatherjackets, they feed on plant roots.

Below: Drone-flies, which busy themselves visiting garden flowers, look remarkably similar to honey bees, but have only two wings, a faster darting flight and the ability to hover. Well-established gardens obviously attract more insects than gardens which have just been made, and gardens in the south of the country abound with more insect life than those in the north.

known are the hummingbird hawkmoth and the silver-Y. Both are migrants, arriving here in late spring and producing a new generation in late summer, and both feed while hovering.

Autumn Earwigs can be found at all times of year, but they are especially noticeable at apple-picking time. Found in all kinds of crevices, they like curling up around the stalks of apples in daytime, from where they emerge at night to nibble holes in the fruit, ruining its keeping qualities. The oak bush cricket is another common inhabitant of the apple tree and of many other trees as well. Active mainly by night, it feeds on other small insects.

Dingy brown craneflies–also known as daddy longlegs–abound in the autumn after spending several months as leatherjackets nibbling the roots under the lawn. These flies like sunbathing on walls, but at night they commonly enter houses and then buzz frantically around trying to find an escape.

Late autumn sees the last of the butterflies with the small tortoiseshell usually the last to hibernate after feeding on nectar from the iceplants and the Michaelmas daisies. Ivy blossom is also a rich source of nectar for many insects, including young queen wasps and bluebottles. At night the ivy blossom is a Mecca for such moths as the beaded chestnut and the green-brindled crescent.

Winter As the days become shorter, swarms of winter gnats come out in the afternoons. The males of these small, harmless, mosquito-like flies form dancing swarms to attract the females. The swarms usually take up station over a fixed object, such as a car, and remain there until dark. These performances go on all through the winter, in all but the very coldest weather.

The winter moth is another hardy species, whose males can be seen on window panes throughout the winter. The females are wingless and occur on the trunks and branches of various trees. Several other moths share the winter nights, including the mottled umber and the drab grey November moth, and when the spring usher makes its appearance–usually in February–we can be sure that spring, with its longer, warmer days, is not far away.

DARTMOOR: HIGH, WILD AND REMOTE

The largest and highest of south-west England's upland regions, Dartmoor–a wild, bleak area of bog and moorland with few settlements–is best known for its granite tors and literary associations which have given it a mysterious and dangerous character.

In 1951 some 945sq km (365sq miles) of Dartmoor were designated as Britain's fourth National Park. This area includes the whole of the old Royal Forest, the common lands around it and also areas of 'in-country' (often of great beauty) which are transitional between moorland and lower-lying agricultural land. Large parts of the north of the moor are military training areas and firing ranges (though the area covered by these used to be much larger), only open to the public when not in use by the military.

A granite landscape Dartmoor is largely made up of granite. In fact, the granitic core represents the stumps of a range of much higher mountains into which the granite was intruded in molten form as the mountains were uplifted by folding. All that remains today is the hard core, since all the overlying rocks have long since eroded away; even the granite core is gradually being whittled down by chemical and physical erosion. The great heat of the molten granite when it was intruded melted or baked the surrounding existing rocks, and this circle of altered rocks–the 'metamorphic aureole', as it is called–can still be detected in the rocks around the moor.

Below: There are not many places left in the British Isles where you can see wild daffodils–collectors and tourists have picked too many of them in the past–but Dartmoor National Park is one of the favoured few sites. Steps Bridge, in particular, is a good place to look for them. Spring, of course, is the time to seek these lovely wild flowers. If you see any, make quite certain that you don't harm any of the plants. This rule does, of course, hold good for any wild plants you may come across–even if the plants appear in a particular spot in profusion, they may be extremely rare–or even non-existent–elsewhere.

At about the same time, or a little later, numerous vapours pervaded the surrounding rocks and the cooling granite, giving rise to many mineral deposits, as well as the vast deposits of china clay around the moor which consist essentially of altered granite.

The granite has a number of peculiar properties that account for many of the moor's characteristics. It weathers rather easily into a moderately fertile to infertile soil called 'growan' where the granite is particularly rotten, though this soil becomes acid and

infertile in the high rainfall conditions of the moor. Because the rotted granite is quite soft, it does not weather into cliffs, so steep-sided valleys are rare, except where bands of harder granite pass across a valley, such as at Tavy Cleave. Harder patches of granite stand out as 'tors', usually at the top of hills, and are often weathered into fantastic shapes. Here and there are outcrops of different rocks which may provide a sharp contrast–for example, the steep hill of Brentor (345m/1130ft) on the western edge of the Park, crowned by its ancient church, is an eroded mass of hard volcanic lava.

Altitude and climate The two other related features of Dartmoor, which give it its distinctive character and which have allowed it to survive for so long, are its altitude and its climate. Much of the moor consists of an undulating dissected plateau at about 400-460m (1300-1500ft), although it rises to over 610m (2000ft) in two places in the north–Yes Tor lies at 619m (2030ft) and High Willhays lies at 621m (2038ft)–and many of the hills around Cranmere Pool in the north-west lie at about 580m (1900ft). The south and east of the moor are generally lower, though even there are occasional hills reaching 490m (1600ft) or 520m (1700ft) in height. One such is Ryder's Hill, at 515m (1690ft). Although hardly comparable with the mountains of northern Britain, this represents the highest

Above: A view of the River Dart in May–with the young leaves on the trees still fresh and light green in colour. Although most people associate Dartmoor with bleak, exposed moorland, there are numerous wooded river valleys which have rich soils on which a wide variety of plants can flourish. The woodland trees provide numerous birds with nesting holes and the clean air permits the growth of a host of lichens, liverworts and mosses.

land mass in southern England.

Inevitably, this high altitude has given rise to a climate markedly colder and wetter than that of the surrounding lowlands. In general, this part of south-west England is very mild, so the climate of Dartmoor is not as severe as in areas further north, though it is harsh enough to make agriculture very difficult. The rainfall at Princetown, for instance, at a height of 414m (1359ft), averages about 2160mm (85in) per year. The higher parts of the moor on the west side probably have an even higher rainfall, while the lower eastern areas probably have considerably less.

Dartmoor's upland bogs Although many parts of the moor have been cultivated at some time in the past, the greater part of the moor is now covered by heathland, acidic grassland and bog, with patches of woodland in the deeper valleys, especially around the edge of the moor.

The high hills and plateaux are mainly dominated by huge areas of bog, with heathland or moorland on the drier areas. The bogs, immortalised (not to say exaggerated!) in Conan Doyle's *The Hound of the Baskervilles*, tend to be dominated by a few species of plants–the bog mosses, two species of cottongrass, various rushes, and cross-leaved heath. The general appearance is one of uniformity, though in fact many of the moor's most interesting plants occur in, or associated with, bogs. The yellow lily-like spikes of bog asphodel, for instance, may be abundant and obvious, often growing with bog pimpernel and the common and intermediate sundews.

In the wetter 'flushes', where the level of

Above: Wheatears can be found in the stonier parts of Dartmoor's heather-clad moorland. Shown here are three juveniles outside their nest hole.

Below: Dartmoor ponies grazing, with Haytor rising grim and menacing in the distance.

Left: A typical view of Dartmoor's heathery hill slopes. This view looks over Headland Warren near Birch Tor.

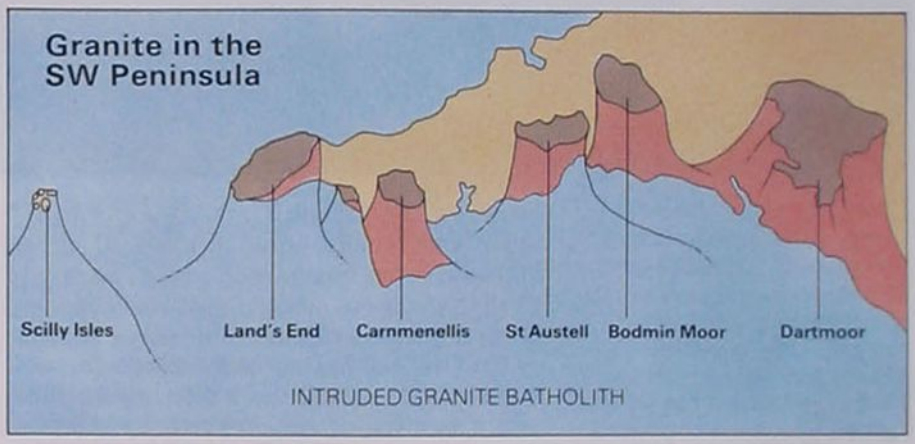
Below: Underneath the South-west Peninsula of England lies an enormous elongated core or batholith of granite which was pushed up, or intruded, into the overlying sedimentary rock some 290 million years ago. In six places this great batholith apears above the land surface in the shape of huge plateaux or upland areas of granite which, because they are harder than the surrounding rock, have tended to withstand the forces of erosion better. Dartmoor is the largest of these, while the offshore Isles of Scilly form the smallest.

nutrients is higher and there is a greater flow of water, the beautiful pale butterwort occurs, with its pale lilac flowers and rosettes of pale green insect-trapping leaves. The rare bog orchid is very occasionally found on the wettest bog moss areas, though it is so inconspicuous that it could easily be overlooked. An even rarer orchid was found some years ago–the Irish lady's tresses; it is confined to just a few places in western Britain, although it has not been seen on Dartmoor for several years now. One other uncommon western species occurring along some of the high streams, as well as lower down in the valleys, is the attractively named (though rather disappointing looking) Cornish moneywort, which trails over the ground in very humid areas.

The bird life of these high bog areas is limited though interesting. The collection of breeding birds consists mainly of curlew, skylarks and meadow pipits, though golden plover and dunlin are recorded very occasionally, and common sandpipers nest sparingly along the streams.

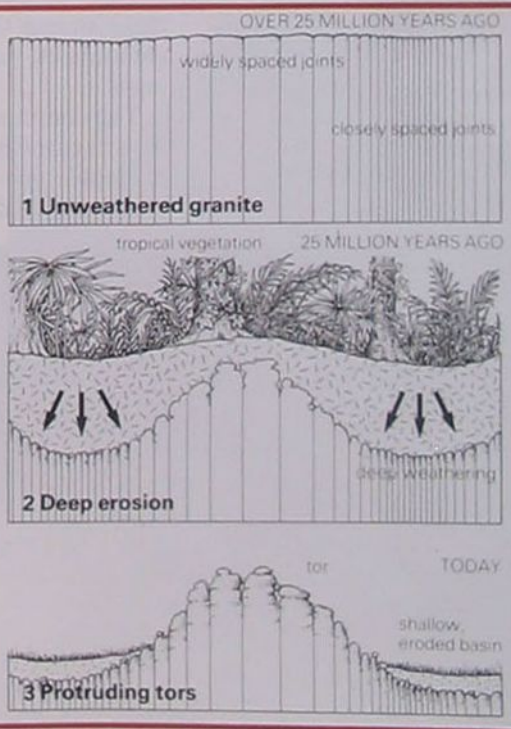
Insects, too, are limited, though the lower valley bogs have a more varied fauna, among which dragonflies are prominent. The hardiest is the large golden-ringed dragonfly, which can be seen high up the moorland streams, while the hawkers, darters and common damselflies tend to stay lower in the valleys, away from the windswept tops.

Heather moorland and tors The drier areas of the high moor are usually covered by wet or dry heath, grading into bog on the wetter areas, and changing gradually to grassland where the peat is more fertile and less waterlogged. There are extensive areas of



Tor formation

The granite of Dartmoor is heavily jointed, the joint pattern including closely spaced and widely spaced areas (**1**). About 25 million years ago the area that is now Dartmoor was under the influence of a much warmer (almost tropical) climate than that of Britain today (as shown by fossil remains). This produced very deep weathering of the granite, but it was not uniform, the closer joints weathering more rapidly than the wider (**2**). The tors were formed largely underground in the area of the widely spaced joints and were exposed by later (possibly Ice Age) erosion (**3**).



Above: Dartmoor (and Exmoor too) is fortunate in being largely pollution-free. This is particularly evident in the crystal clear streams of the area. This moorland stream near Belstone is a perfect example. (The red-berried tree in the centre is a rowan, or mountain ash.)

Below: A plant to look for in the woodland valleys of Dartmoor National Park–the attractive ivy-leaved bellflower.

heather moor, though it is rarely uniform, and there are usually some patches of grass, bracken, gorse, bog or rock with it, according to the conditions and its past management. Some parts are a riot of colour in late summer as the ling, bell heather and western gorse all flower together, and the whole impenetrable sward is often densely covered by the pink strands of the parasitic dodder. Here and there among the heather there are patches of clubmosses, particularly the stag's-horn clubmoss.

The commonest birds by far on the heather moor are the meadow pipits and skylarks: for example, one survey of 132 hectares (326 acres) revealed 94 meadow pipits, 78 skylarks and nothing else–except one stonechat and one cuckoo (which regularly uses meadow pipit nests here). In fact, both stonechats and whinchats are reasonably widespread where there is taller vegetation, and wheatears occur as well, particularly in the stonier areas or along walls. Ring ouzels breed sparingly, often where there are rocky outcrops at the heads of valleys, and wrens are common in the same habitat.

Walkers on the moor occasionally come across a large bright green and black caterpillar. This is the larva of the beautiful emperor moth, which flies on the moor during the spring. Almost as striking, and rather commoner, are the bristle-covered caterpillars of the fox moth, frequently parasitised by ichneumons. One of the most conspicuous insects is the attractive bumble bee *Bombus lapponicus*, a northern species which comes this far south only on the highest hills. Dor beetles are frequent and obvious as they bumble about searching for dung, usually in the evening but occasionally during the day. The butterflies most often found are the small heath, meadow brown and common blue.

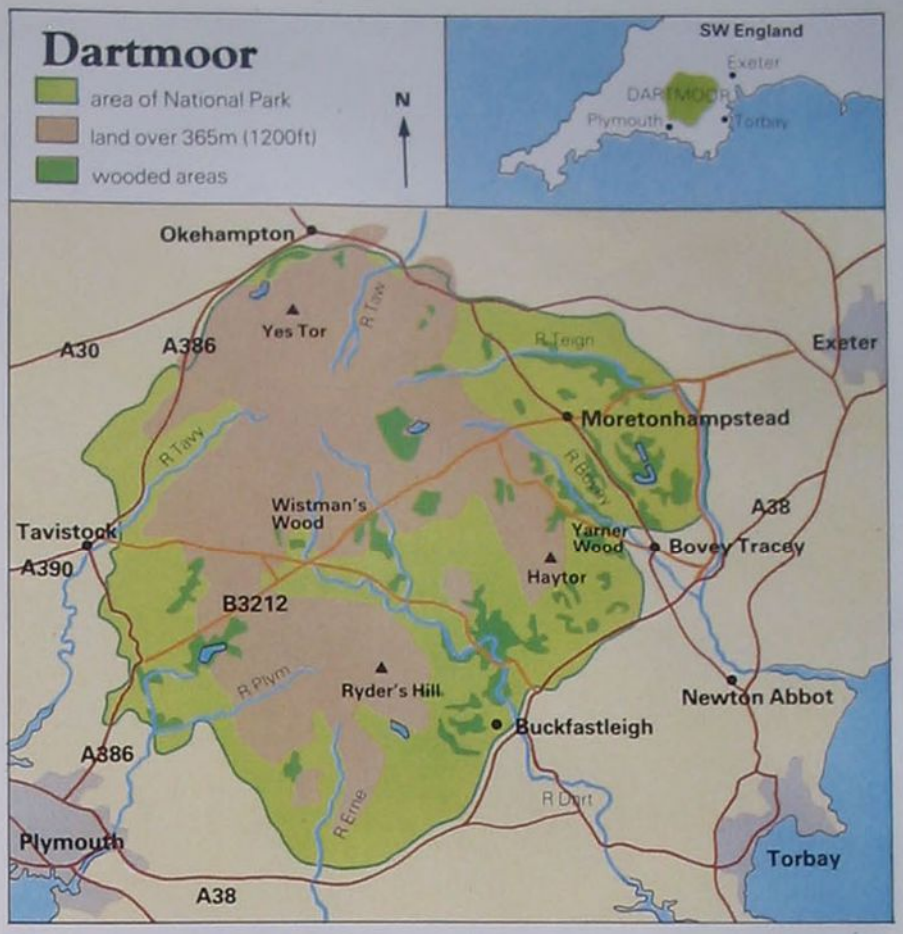
The tors, which rise above the moors, are virtually devoid of life, except that they provide an ideal substrate for numerous lichens, a foothold for a few ferns and cover for various invertebrates such as bristletails and harvestmen. Below them there are often extensive areas of scree or 'clitter'; these may

be almost completely bare where they are new or very unstable, while in other places they provide the ideal habitat for woodland to develop, with the seedling trees temporarily sheltered from grazing.

Dartmoor's woodlands Although the moors and tors are the most obvious and best known features of Dartmoor, there are numerous woodlands, particularly around the edge of the moor, which are havens for wildlife. There are a number of high altitude oakwoods, such as Black Tor Copse and Wistman's Wood, which are exceptionally interesting ecologically as examples of woods growing under extreme conditions. Lower down, though, where the valleys deepen as they leave the moorland, there are extensive and beautiful oakwoods, around the Bovey Valley for instance, where Yarner Wood National Nature Reserve lies, and also in the middle reaches of the Rivers Dart and Webburn. The higher parts of these woods are usually sessile oak, while lower down the soil is richer and common, or pedunculate, oak becomes dominant, together with a richer ground flora.

Most of these woods are excellent habitats for breeding birds, with plenty of holes for such species as redstarts, stock doves and pied flycatchers, while other species–from buzzards to wood warblers–are common. They are enthralling places in the early summer, alive with bird-song and flowers. Perhaps not surprisingly in the clean humid air of south Devon, they are also rich in lichens, mosses and liverworts, often growing in profusion over the trees as well as the ground.

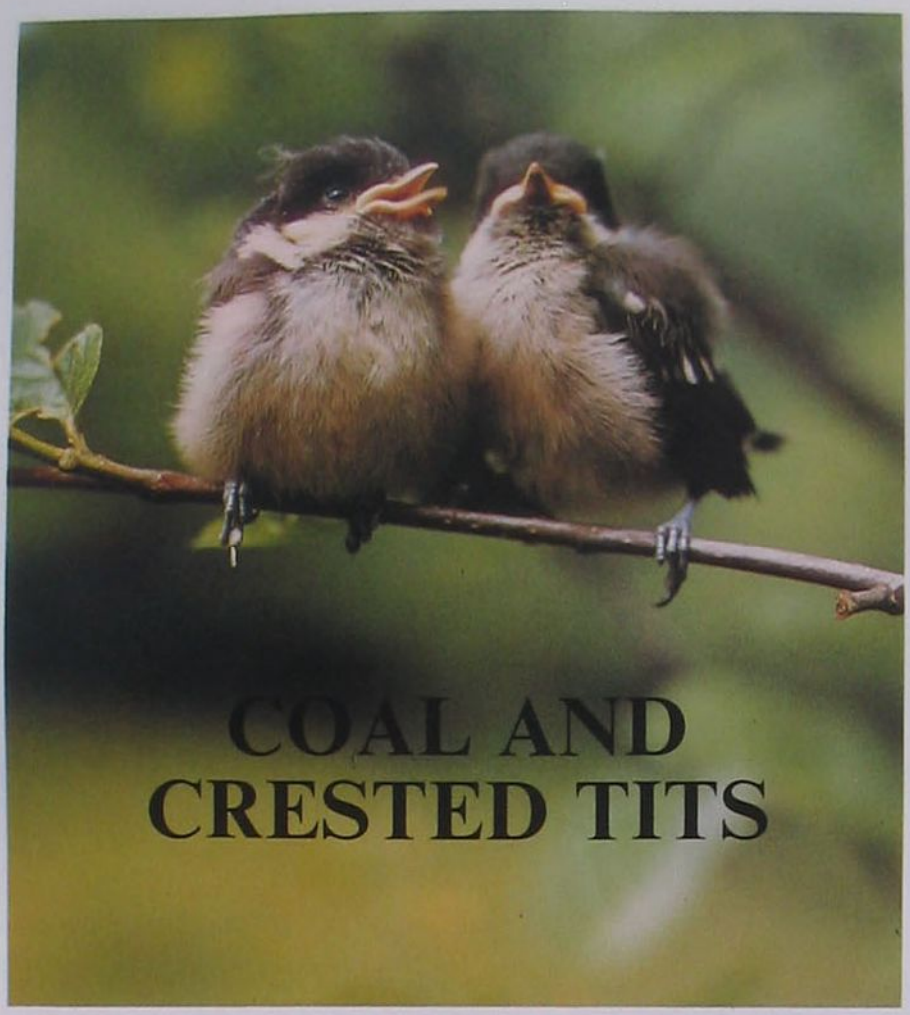
So, although one's first impressions of Dartmoor may be of uniformity and barrenness, in reality it is a varied landscape providing habitats for an enormous range of plants and animals. However, the landscape is not quite as stable and unchanging as it first appears. Extensive forestry planting has altered the character of many an open hillside, while the combination of overgrazing and overburning is progressively altering areas of moorland towards grassland or bracken. Nevertheless, Dartmoor substantially remains an unspoilt wild island high above the soft farmland of Devon.



Above: A map of Dartmoor National Park, showing some of the places of interest. Remember that Dartmoor is a bleak, exposed and lonely place and never set off for picnics or walking tours without a good map, suitable footwear and adequate clothing and other provisions. Beware, in particular, of the treacherous upland bogs and the mists that can fall with frightening rapidity.

Right: This slug, *Arion ater,* does well in the damp, mild atmosphere of Dartmoor and is easy to find on the high moors in damp weather.

Left: A female emperor moth resting on gorse; she most often flies by night. The males of this magnificent moth are on the wing in daylight, and can be seen flying at speed among the heather on Dartmoor in April and May. The emperor moth caterpillar–bright green with black markings–feeds on a variety of plants, including sloe, sallow, heather and bramble.



COAL AND CRESTED TITS

The coal tit is associated with coniferous woodland, but it is the crested tit which, although less numerous, is the true conifer specialist.

Above: Young coal tits on an alder branch. Before long they will take on a fully adult appearance and become independent.

Below: An adult coal tit, identifiable at once by its white head patch.

For most birdwatchers, the coal tit is *the* typical tit of conifers–be they extensive commercial plantations, a farmland windbreak of Leyland cypress or even a group of specimen trees in a largish garden in town or country. Despite a clear preference for conifers, coal tits are by no means restricted to them, and in years when the coal tit population is high they may be found in mixed and even in purely deciduous woodland.

High in the concealing canopy of conifers, small, actively moving birds are often difficult to spot, so the presence of coal tits is usually signalled by their calls. Most distinctive of these is a plaintive 'tsuuu', but a high-pitched 'tsee-tsee-tsee' (similar to the calls of other tits and the goldcrest) is sometimes used. In the breeding season, males proclaim their territories vocally, often from high song posts. The song, although repetitive, is a tuneful piping 'tee-chu, tee-chu, tee-chu', with the emphasis on the first syllable. This can be distinguished from the bold, ringing 'teacher, teacher' song of the male great tit.

An almost spherical bird Having located the birds by ear, you can then look at them. Coal tits are small–smaller than blue tits and only a little bigger than goldcrests–and they are conspicuously dumpy in appearance, with an almost spherical, apparently neckless body and long, spindly legs. The most immediately striking feature, in both sexes, is the head pattern. The crown, sides of the nape, throat and upper breast are glossy black, offsetting the coal tit's bold white cheek patches and the characteristic white triangle on the back of the head. This white triangle is a useful separation feature from the great tit, particularly if the head is all that can be seen.

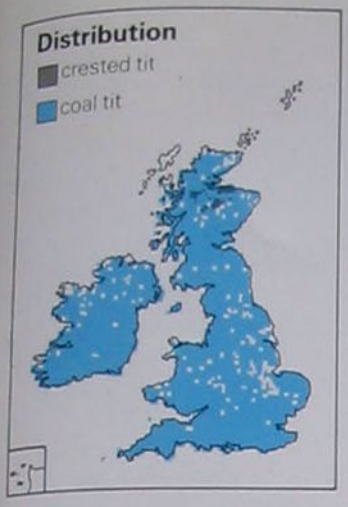
The body is olive-grey above, and buff below (sometimes pinkish or rusty coloured, but never as yellow as in the great tit). The wings are dark brown, with a double wing bar visible on the closed wing.

Three distinct races The coal tit is very widely distributed across Britain and Ireland, being absent only from the Hebrides, Orkneys, Shetland and some treeless areas in the fens of England and in the extreme west of Ireland. Most British and Irish birds are residents, and although they move around the countryside, they rarely migrate in the true sense. Thus local populations have developed into distinct races.

A race called *Parus ater hibernicus*, with a yellowish tinge to the white patches on its cheeks and nape, occurs in Ireland, Wales and western Scotland. The main race is *Parus ater britannicus*, and it also occurs throughout the range of the Irish race. The Continental race, *Parus ater ater*, which is more richly coloured, is seen in most years in autumn on the east coast of Britain: the numbers that arrive from the Continent vary with the severity of the European winter.

Coal tit numbers The *Atlas of Breeding Birds*

Conifer-loving birds



in Britain and Ireland estimated that in 1972 the coal tit population was around one million pairs–about one third of the population estimate for the great tit and one fifth of that for the blue tit. Coal tit numbers are subject to great variation from year to year, as the birds suffer very high mortality in cold winters; the chief reason for this is that prolonged snow conceals their food sources.

Food hoarders Coal tits are catholic in their diet, eating insects and their eggs and larvae at all times, seeking them out among twigs of the tree canopy with great agility. When available, a wide variety of seeds, fruit and nuts are eaten, and in many areas coal tits are regular visitors to garden bird tables. They have an endearing habit of taking food (particularly peanuts) away to cache in a suitable cranny in nearby ivy or among the needles of a yew tree.

Hole nesters In woodlands (where they are often encouraged as a means of keeping down insect pest numbers) and in gardens, coal tits take readily to nest boxes, but their natural sites are usually holes in trees or crevices in buildings or walls. The nest is of moss lined with hair and fur, and is built by both parent birds. The usual clutch of small brown-freckled white eggs is between 7 and 11, and these are incubated by the female, usually for 14 days.

Both sexes share in feeding the brood, which fledges 16 or more days after hatching, depending on the weather. Many pairs in the south have complete clutches before the end of April, and it may be that second clutches in warmer areas are more common than is usually thought.

A true conifer specialist The crested tit is widely distributed in Continental Europe, breeding in coniferous woodland and forests of varied types from southern Spain to central

Coal tit (*Parus ater*). Resident in woodland, with a preference for conifers. Sexes alike. 12cm (4½in).

Crested tit (*Parus cristatus*). Resident, restricted to Scottish pine forests. Length 12cm (4½in).

Left: Crested tits have a number of calls: most are short and high-pitched, and similar to those of other tits. More characteristic is a lower-pitched, rather irregular trill.

Above: For much of the year crested tits feed on insects and their eggs and larvae, augmenting this diet when other foods such as pine seeds and rowan berries are available.

Left: A coal tit outside its nest hole in a rock crevice. The nest is often close to ground level, and there are many records of nests in banks or even in abandoned mouse holes.

Below: A coal tit on larch cones, which are nearly as big as the bird. The narrow double wing bar is visible even on the closed wing. It may well be asked why coal tits show such a strong preference for coniferous trees, while able to live in broadleaved woodland. Research has shown that one reason is that the coal tit has a narrower beak than other tits, enabling it to extract small insects from between the closely spaced needles of conifers. Interestingly, those living in broadleaved woodland have thicker beaks.

Scandinavia. Because of this, it is surprising to discover that in Britain it is the scarcest of the tit family, and the most restricted in distribution. Of all the tits, the crested tit is the best adapted to live in conifers, and in consequence it might have been expected to benefit greatly from the extensive coniferous reafforestation programmes of the last few decades. Such is not the case, however, and the total population of around one thousand pairs is restricted to a small area of the Highlands of Scotland in the glens around the Spey and Loch Ness. Within their stronghold in this area, crested tits are remarkably sedentary all their lives, rarely moving more than a kilometre or two from the place of their hatching.

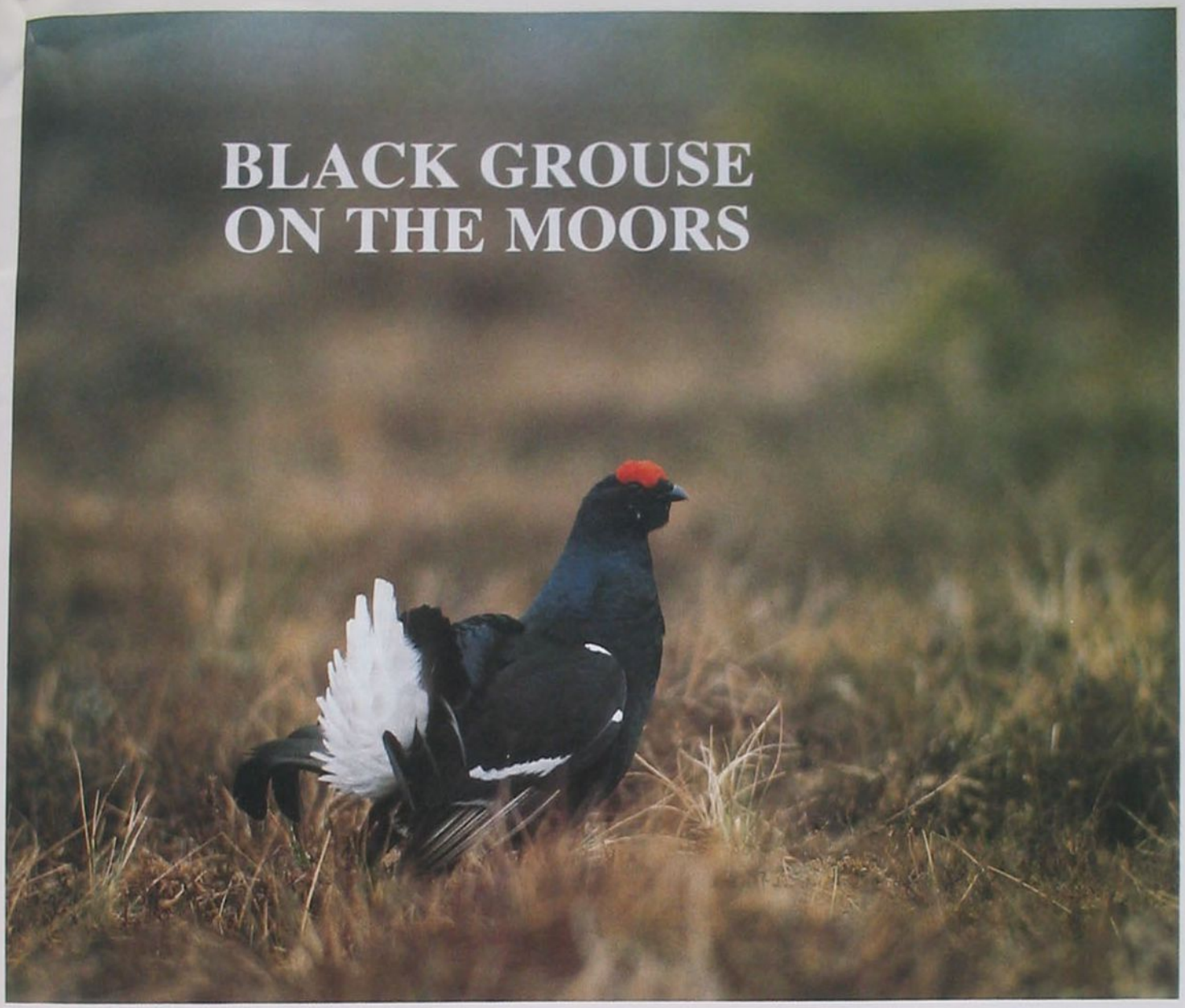
This area corresponds largely to that covered by the scattered remains of the once extensive Caledonian Forest of Scots pine, and for most of the year this open woodland of aged pine trees, with a scattering of alder and birch, is the crested tit's prime habitat. In severe weather the birds are hard pressed to find sufficient food, and can be seen scavenging for morsels of fat on carcases of deer and sheep that have succumbed to the winter. At such times they are regular visitors to garden bird tables, even though there are not many of these in this area. Crested tits display great acrobatic agility, like other tits, but do not occur in large flocks.

The pointed crest Relatively few of our small birds have such an immediately noticeable distinguishing feature as the crest of the crested tit. The bird is much the same shape and size as a blue tit, and as nimble and unpredictable in its flitting movements. The immediate impression of colour is of a mixture of soft browns, darker above, paler below, as in the willow or marsh tits. The similarity with these two species continues as far as the throat, for the crested tit, too, has a striking black bib. But there the resemblance to other tits–or to any other bird–ceases. As its name implies, the crested tit has a long, pointed crest, which is marked with black and white vertical bands. This, together with its broad white cheek patches, which are black bordered and have a crescent-shaped mark in the centre, makes it easy to identify. The black and white crest and white face are duller in immature birds.

Wood diggers Like the willow tit, crested tits excavate their own nest holes, usually in the decaying stump of a Scots pine but occasionally in a birch or alder. There are some records of pairs using nest boxes, and this number could perhaps be increased if the boxes were filled with balsa wood or compacted sawdust, so that the crested tits could 'excavate' the nest cavity.

Breeding begins early (especially for birds living so far north), most pairs having eggs in the second half of April. The normal clutch is of 5-8 tiny red-freckled white eggs, laid in a moss nest. The nest is often lined with the hair of deer or mountain hares, and is constructed largely by the female. She performs the task of incubation on her own, which takes about a fortnight, and she shoulders most of the burden of feeding the young, which fledge 16 to 20 days after hatching. Second broods seem to be rare.

BLACK GROUSE ON THE MOORS



Although not a common gamebird, the black grouse is exciting to watch, with its ritual contests and matchmaking in the arena or 'lekking' ground.

The British Isles boast few birds that occur nowhere else in the world, but the race of the black grouse that occurs here is unique. This is a bird of moorland or heathland with scattered clumps of trees or open young coniferous or birch woodland–it prefers the margin between woodland and moorland. This kind of habitat is locally widespread, and the black grouse used to occupy such areas in southern and eastern counties of England. However, it can no longer be seen in Surrey, Sussex, Dorset, Hampshire, Norfolk or Lincolnshire, and even where it still occurs its numbers are much smaller than in the late 19th century.

Although shooting and man-induced changes in the vegetation of some otherwise suitable areas have certainly contributed to these local extinctions and declines, the reasons underlying them are not really understood. There have been many attempts to reintroduce the black grouse into areas where it has declined or disappeared, but with only partial success. Black grouse do not occur in Ireland, and all attempts to introduce them to that country have failed.

Second largest gamebird Black grouse are fairly large gamebirds. With a body length of 40-55cm (16-22in) they are larger than red grouse and partridges, but smaller than the capercaillie. The male, called the blackcock, is unmistakable with his glossy blue-black plumage, long outwardly curving tail feathers and white wing bar and undertail feathers. A white spot at the base of the leading edge of each wing is made conspicuous during display, as is the red wattle above the eye. The female, or greyhen, is a much duller bird, the colour of her plumage being designed for camouflage. Above, she is a warm brown, while her belly is greyer, but all of her body is spotted and barred with black. Juveniles are

Above: The adult male black grouse, or blackcock. These normally begin breeding at three years old, while the females (or greyhens) start earlier. For a large bird, the species is short-lived–the oldest ringed bird being only five years old.

Above: A greyhen broods her newly hatched young. She has not yet had an opportunity to tidy away the egg shells (which might attract attention) for it is rainy and her first priority is to keep the downy chicks dry and warm. She continues to brood the chicks at night and during rain for ten days. For safety, she may move away from the nest within a few days, to a distance of half a kilometre or more. At a fortnight old the chicks can fly short distances.

similar to hens until their first winter, when young males resemble adult males, though their backs still show signs of barring and the tail feathers are shorter.

Mainly vegetarian Black grouse are essentially a vegetarian species, though the birds do eat some insects in the summer. In spring, summer and autumn they feed mainly on the ground, but in winter they feed in bushes and trees: this explains their requirement for a mixture of open ground and woodland.

The winter habit of feeding in trees can lead to forestry damage, for the buds and shoots of conifers are sometimes eaten. Pine needles and cones, birch catkins, heather and grasses also contribute to the winter diet. In summer, various berries such as bilberries, and the nutritious growing shoots of heather, constitute the preferred foods.

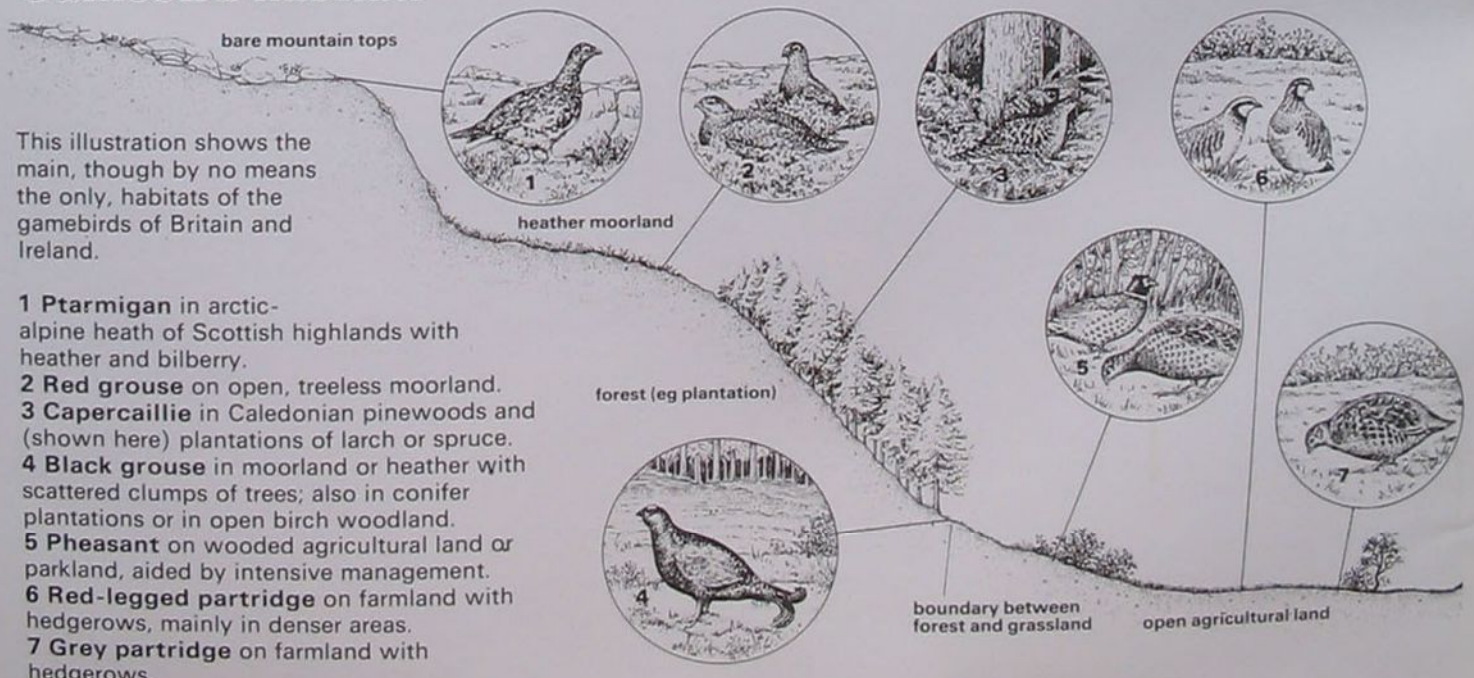
This vegetable diet supplies the full-grown birds with all their needs, but the extra protein requirements of rapidly growing chicks are met by a mainly animal diet. Insects, predominantly ants, are the main constituent of the food of very young chicks, but after a day or two they also take increasing numbers of berries and fruits.

Tending the young The black grouse normally nests on the ground, but occasionally makes use of old nests of other birds in trees. The nest is a shallow depression and is fashioned by the greyhen, who lines it with grasses and other fine plant material. She lays between six and eleven eggs, at 36 to 48-hour intervals during May and June, and incubates these for 25 to 27 days. The nest is usually well hidden under a tussock of grass or in scrub, and the eggs themselves are protectively coloured, being buff with brown spots.

Although hens are solitary nesters, probably as a protection against predators, black grouse are nevertheless gregarious birds, especially the blackcocks, which form their own flocks in winter. The hens and first-year males form mixed flocks, and they rarely associate with the blackcocks.

Breeding behaviour The most intriguing aspect of the black grouse's social life, however, is what is known as 'lekking' behaviour. This can occur around dawn and dusk throughout the year, but does so especially during autumn and spring, with the most intense and prolonged bouts in spring. Within the range of a group of grouse, the blackcocks assemble each day at an open piece of ground, termed the 'arena', where they display or 'lek'.

Gamebird habitats



This illustration shows the main, though by no means the only, habitats of the gamebirds of Britain and Ireland.

1 Ptarmigan in arctic-alpine heath of Scottish highlands with heather and bilberry.
2 Red grouse on open, treeless moorland.
3 Capercaillie in Caledonian pinewoods and (shown here) plantations of larch or spruce.
4 Black grouse in moorland or heather with scattered clumps of trees; also in conifer plantations or in open birch woodland.
5 Pheasant on wooded agricultural land or parkland, aided by intensive management.
6 Red-legged partridge on farmland with hedgerows, mainly in denser areas.
7 Grey partridge on farmland with hedgerows.

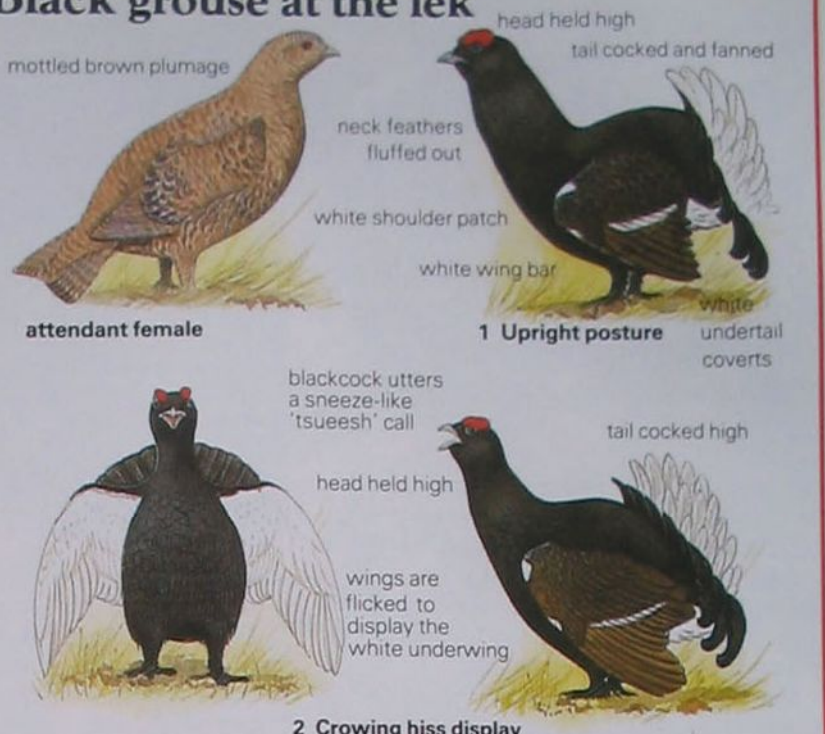
Arenas are traditional lekking sites, and some are known to have been used as such for over 50 years. Within the arena, the males establish territories. Each territory averages about 100 square metres and the territories may be visited by intruding non-territorial birds, who are usually driven out, and also by hens. The number of territory-holding blackcocks varies from arena to arena, but a dozen or more individuals may be involved–all competing strongly against each other.

The arena is the area where most copulations occur, and from the male's point of view it is important to hold a territory near the centre of the arena, for central males achieve more copulations than do peripheral ones. Thus the arena, with its associated lekking behaviour, gives the males an opportunity to display their prowess, and the females to choose the best males with which to mate.

The chief reason why the males are able to find so many females to mate with is that the black grouse as a species does not form a pair bond between breeding partners. The birds are highly promiscuous, and males attempt to mate with any females that land or walk through their territories. Females are particularly attracted to fighting and copulating males.

The intriguingly complex social behaviour in the lek must have evolved as a means of ensuring that sufficient young are produced to maintain the black grouse's population. In this, the species seems to have failed during the present century, doubtless due largely to a variety of man's influences. Attempts at managing the land for black grouse are less enthusiastic than with other British game because black grouse are described as 'determined and unpredictable' birds on the shoot–in short, they are not very sporting!

Black grouse at the lek



This illustration shows some of the lekking behaviour in the arena of the black grouse. The **upright posture (1)** is an aggressive stance used in defence of the territory. The males indicate possession of a territory by the **crowing hiss display (2)**, which induces other males to display and attracts females to enter the arena. The commonest display is the **rookooing call (3)**. This is both a courtship and a territorial display, for greyhens are attracted by the sight of a blackcock vigorously defending his territory.

Left: Three blackcocks sorting out a territorial dispute in the arena. If a dispute breaks out between two birds near the boundary of a third territory, the occupier of this territory is likely to join in and ensure that the matter is not settled at his expense. Confrontations like this involve much use of the upright posture, as well as frequent bowing, but actual fighting is uncommon. In nearly all cases a decision is reached without violence–one bird surrenders, adopting a submission posture with wings trailing, and is chased off.

Black grouse (*Lyrurus tetrix*). Large gamebird resident on moors and heaths in Scotland, England and Wales. Length 55cm (22in).

INSECTS IN PERSPECTIVE

With 800,000 insect species in the world it has been necessary to devise a method of classifying them. Despite the vast numbers, they fall into relatively few orders.

The word insect is popularly applied to any small creature that scuttles or flies away when disturbed, or that bites. However, a grasp of biology is needed for you to be able to recognise all insects, as such, with any degree of certainty, and to be able to distinguish one from other invertebrate animals.

The phylum Firstly, insects belong to the vast phylum of the Animal Kingdom called Arthropoda. Members of this phylum have bodies divided into segments, some or most of which carry a pair of jointed limbs. The body and limbs are covered by a hardened cuticle with flexible membranes between the segments, allowing movement.

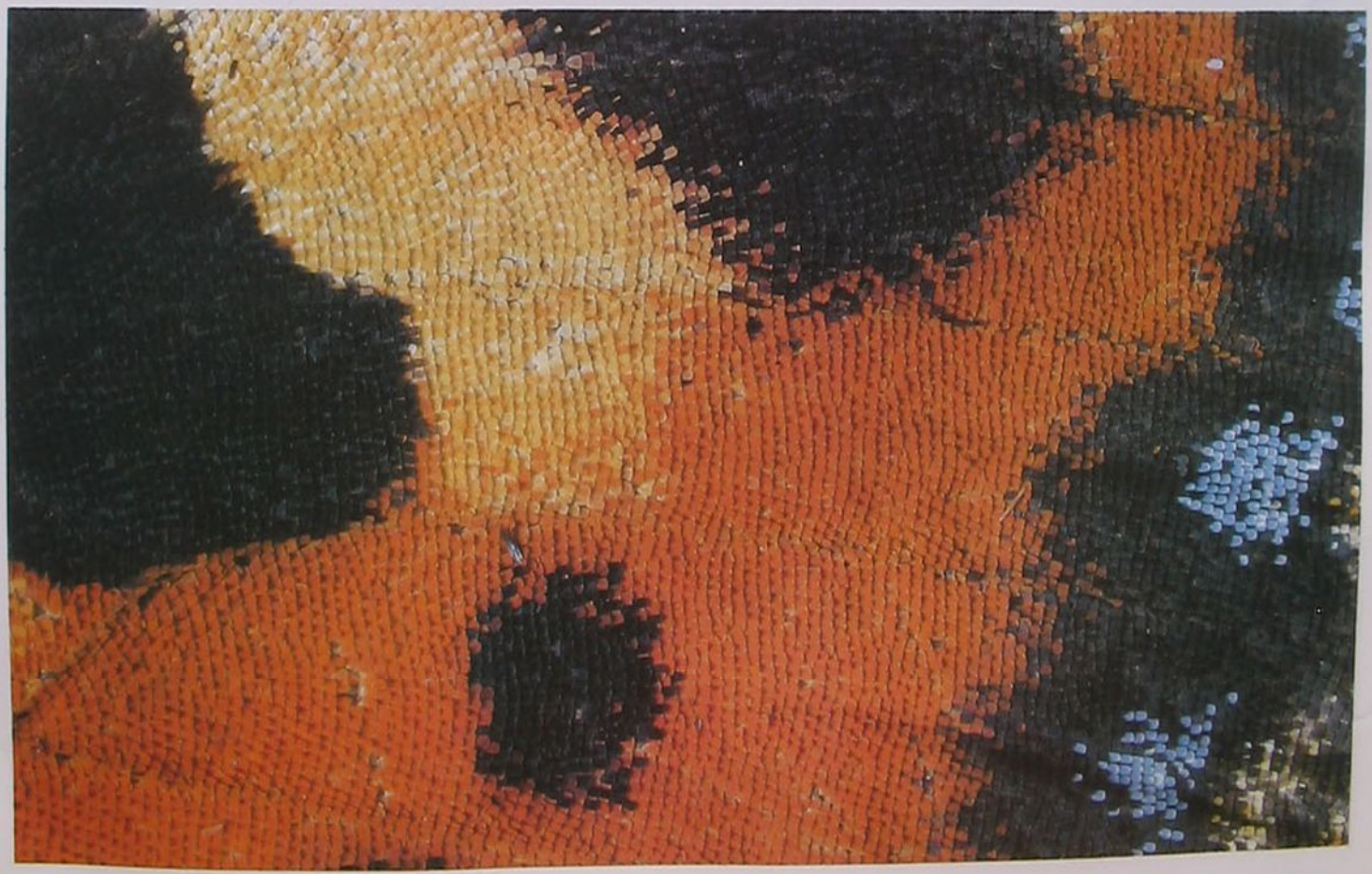
The Arthropoda is the largest phylum of animals and contains at least 85% of all animal species. Besides the true insects (Insecta), it includes the crustaceans and the arachnids (spiders and mites), each of these groups being called a class.

The insect class Insects form by far the largest class of the Arthropoda–about 800,000 separate species having been described worldwide, with many more still to come. Nearly 22,000 of these occur in the British Isles alone. Characteristics possessed by all adult insects are: the grouping of the body segments into three regions–head, thorax and abdomen; the presence of one pair of antennae; and the possession of three pairs of legs on the thorax. Most have wings as well.

Larvae (the young stage of those with a complete life-cycle) often differ profoundly from the adults and may not be immediately

Above: Members of the Coleoptera or beetle order are easily recognised by their hard forewings (elytra) which meet in a straight line down the back (seen on this tiger beetle), protecting the soft hindwings.

Below: Butterflies and moths belong to the order Lepidoptera, meaning scaly wings. The insects' colours reside in these scales, seen clearly in this close-up of a small tortoiseshell's wing.



recognisable as insects. They do not have wings, their antennae are hardly visible and the legs may be absent, although some may have true legs as well as extra false legs on the abdomen.

Insect subclass The class Insecta is split into two subclasses, the Apterygota (wingless insects) and the Pterygota (winged insects) –some wingless insects are grouped in the Pterygota as they are considered to have lost their wings in the course of evolution.

The Apterygota include bristletails and springtails. They are small and live in soil or damp crevices. Their young look like small versions of the adults, and the adults continue to moult after reaching sexual maturity.

The Pterygota are divided into two groups, based on their life histories. The Exopterygota have what is known as an 'incomplete life-cycle' with young, called nymphs, which look similar to the adults, and have externally developing wings resembling pads on their thorax. They have no pupal or resting stage. The Endopterygota (with a complete life-cycle) have young called larvae–grubs or caterpillars–which are often quite unlike their adults. Their wings are not externally visible until the pupal stage. It must be stressed that, with the exception of mayflies, no adult pterygote insect moults.

These major splits are of great use in theoretical and evolutionary studies, but entomologists are normally more interested with the next grouping–the order–each of which includes insects obviously related to one another, as in dragonflies, beetles, or butterflies and moths.

Exopterygote orders Among the better known orders of the Exopterygota is the Orthoptera, now restricted to the jumping species–grasshoppers and crickets–each with enlarged hindlegs, straight forewings, and the ability to attract the opposite sex by 'singing'.

The hemipteroid orders–also pterygotes –grouped around the central order Hemiptera (true bugs) all show a specialisation of their mouthparts, culminating in the bug's sucking rostrum. Many Hemiptera look vaguely like beetles, but they can always be distinguished by their sucking rostrum and by the wings which are either held roof-like (aphids and leaf-hoppers) or flat on the back with over-lapping membranous parts.

Endopterygote orders The Endopterygota include most of the particularly successful insects. The evolution of their larval and pupal stages has enabled the larvae to utilise and exploit food and niches not available to the adults.

The Coleoptera (beetles) are a large and compact group recognised by their chewing mouthparts and by the hard forewings (elytra) which meet in a straight line down their back.

Another order, the Diptera (true flies), have only one pair of flying wings, the hind pair having been converted to tiny knobbed structures called halteres or balancers. These vibrate rapidly in flight, helping to control the flight direction. The Diptera have sucking mouthparts which, in some families, are adapted for piercing the skin of vertebrates to suck their blood. In all Diptera larvae the true legs are absent and in the more highly evolved species the larval head has all but vanished.

The Lepidoptera (butterflies and moths) are familiar to everyone. Their name means 'scaly wings' because all their colours reside in the layer of flattened scales that covers their wings and body. Their mouthparts are highly modified to absorb nectar and their larvae are caterpillars, the pupal stage being called a chrysalis.

The last main order, the Hymenoptera (bees, wasps and ants) have an extremely highly developed biology and a complex life-style. The mouthparts may be of a simple chewing kind, but in the higher forms they are usually the lapping or sucking type. They have two pairs of wings, the front ones and hind ones of each side being held together in flight by a row of tiny hooks; and most species have a well developed 'wasp waist' (constricted waist).

Family, genus and species Each order is divided into families, the Latin names for which all end in '*-idae*', and each family is divided into a number of separate groups called genera. Each genus is finally divided into species, which are the individual kinds of animals.

The most easily understood definition of a species is that the members of one species are able to interbreed and produce fertile offspring, whereas separate species either do not interbreed or, if they do, produce sterile offspring.

Above: Honey bees belong to the order Hymenoptera, meaning 'membrane-winged'. Other members of this order include sawflies, gall wasps, parasitic wasps, social wasps, and all ants and bees. Although they have many simple body features, the organisation of their life-styles is extremely complex, as can be observed in the activities of a honey bee hive, in which as many as 80,000 bees co-operate to maintain the nest and look after the young.

Latin names

In the Latin names used internationally by biologists, the first word–with an initial capital letter–is the genus (for example, *Apis*) and the second word, with a small initial letter, is the species name (*mellifera*). Latin names of the genus and species are printed in italics (*Apis mellifera*), while higher groupings (the order Hymenoptera) are written in Roman upright letters. This method of giving each species two words was devised by Linnaeus, the Swedish botanist, in the 18th century.

The diverse insect class

1 2 3 4 5

Left: **Thysanura (bristletails):** small and wingless with smooth bodies and 3 tail filaments. Right: **Diplura (bristletails):** 2 tail filaments.

Left: **Protura:** minute wingless soil insects with no antennae. Right: **Collembola (springtails):** wingless, with forked organ below abdomen.

Ephemeroptera (mayflies): tail filaments and 2 pairs of unequal, netted wings.

25

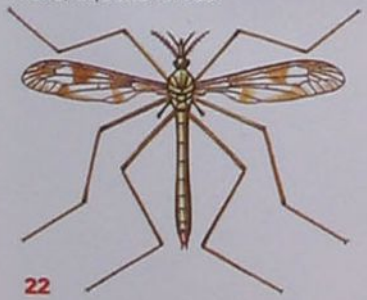
Hymenoptera (bees, wasps, ants): 4 membranous wings, waisted bodies, highly evolved.

24

Lepidoptera (butterflies, moths): clothed in scales, coiled sucking mouthparts.

23

Trichoptera (caddisflies): moth-like but wings clothed in hairs, aquatic larvae.



22

Diptera (2 winged flies and midges): only forewings developed, sucking mouthparts.

21

Siphonaptera (fleas): bodies flattened sideways, hopping blood-sucking parasites.

20

Mecoptera (scorpion-flies): head drawn out to snout, 4 narrow wings.

19

Strepsiptera (stylops): bag-like females, male forewings reduced to knobs.

18

Coleoptera (beetles): hardened forewings meeting in straight line on back.

INSECTA

Class	Subclass and Division		British Orders	
	APTERYGOTA (wingless insects)	1	**Thysanura**	bristletails
		2	**Diplura**	bristletails
	little or no metamorphosis	3	**Protura**	tiny soil insects
		4	**Collembola**	springtails
	PTERYGOTA (winged insects)	5	**Ephemeroptera**	mayflies
		6	**Odonata**	dragonflies
	EXOPTERYGOTA	7	**Plecoptera**	stoneflies
	incomplete metamorphosis	8	**Orthoptera**	crickets
		9	**Dermaptera**	earwigs
		10	**Dictyoptera**	cockroaches
		11	**Phasmida**	stick insects
		12	**Psocoptera**	booklice
		13	**Mallophaga**	chewing lice
		14	**Siphunculata**	sucking lice
		15	**Hemiptera**	true bugs
		16	**Thysanoptera**	thrips
	ENDOPTERYGOTA	17	**Neuroptera**	lacewings
	complete metamorphosis	18	**Coleoptera**	beetles
		19	**Strepsiptera**	stylops
		20	**Mecoptera**	scorpion-flies
		21	**Siphonaptera**	fleas
		22	**Diptera**	true flies
		23	**Trichoptera**	caddisflies
		24	**Lepidoptera**	butterflies
		25	**Hymenoptera**	bees, wasps

6

Odonata (dragonflies, damselflies): equal wings, long abdomen, carnivorous feeders.

7

Plecoptera (stoneflies): weak fliers, 2 long tail filaments, wings held flat on back.

8

Orthoptera (grasshoppers, crickets): enlarged hindlegs for jumping, males can sing.

9

Dermaptera (earwigs): large hindwings folded below small forewings, tail pincers.

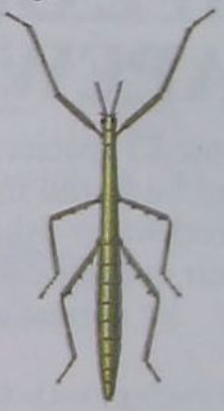
Number of British Families	Number of British Genera	Number of British Species
2	6	9
1	1	12
3	6	12
9	53	304
8	18	46
9	21	45
7	16	34
10	21	30
3	6	7
3	5	8
1	3	3
11	30	87
7	84	514
5	12	25
61	537	1672
3	43	159
7	19	60
96	967	3845
3	4	15
2	2	4
6	26	57
87	1233	6000
14	70	192
61	900+	2400
66	1300+	6000+
example; Apidae (bees)	*Apis*	*mellifera* (honey bee)
	Bombus	*terrestris* (large earth bumblebee)
		lucorum (small earth bumblebee)

How it all works

When identifying a species, entomologists first try to place the specimen in an order. Each order includes insects which are related to each other and have certain common characteristics. For example, all Lepidoptera (butterflies and moths) have scaly wings and highly modified mouthparts. The orders then divide into families, the Latin names for which all end in *-idae,* which in turn divide into groups named genera (singular genus). Finally the genera split into species which are individual insects. Hence the small white butterfly (*Pieris rapae*) belongs to the genus *Pieris,* the family Pieridae, and the order Lepidoptera.

10

Dictyoptera (cockroaches): tail appendages, leathery forewings cover fan-like hindwings.



11

Phasmida (stick insects): twig-like bodies and legs, no wings, long antennae.

12

Psocoptera (booklice): small, soft-bodied, some with wings, large head and conspicuous eyes.

17

Neuroptera (lacewings, alderflies and snakeflies): soft bodies, wings held roof-like.

16

Left: **Thysanoptera (thrips):** sap-sucking insects with narrow wings. Right: **Hemiptera (true bugs, plant lice):** sucking mouthparts, leathery forewings.

15

14

Left: **Siphunculata (mammal/sucking lice):** wingless, blood-sucking parasites. Right: **Mallophaga (bird/chewing lice),** non blood-sucking parasites.

13

THE SECRET LIFE OF FISH TAPEWORMS

Some 23 species of tapeworms can be found inside Britain's freshwater fishes, living out their complex lives unnoticed by almost everyone.

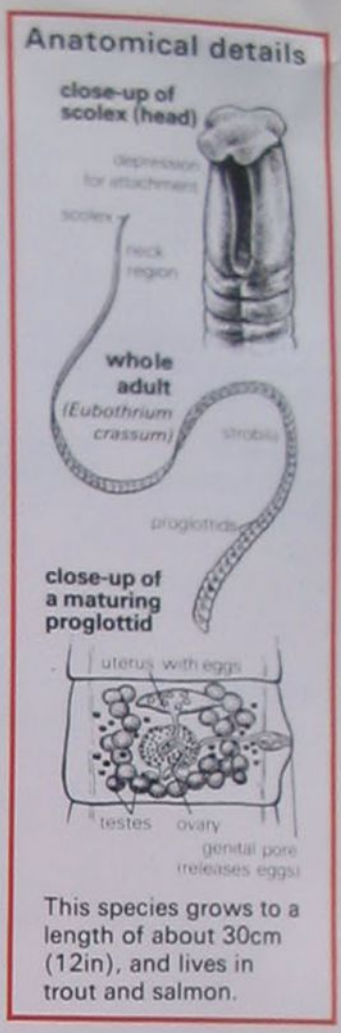
Most people try not to think of tapeworms at all, but if they do, they do so with repugnance and in the belief that only animals such as cattle, pigs and man are infected. However, all vertebrates and most invertebrates, aquatic and terrestrial, can serve as hosts to these sinister but fascinating parasites. At least 23 species of tapeworms can be found in the 55 species of British freshwater fishes, living out their complex lives unnoticed by all except the parasitologist and occasional angler.

Most species are fairly common and widespread, though each is restricted to a particular species or group of related species of fish. The habitat of the parasite is essentially that of the fish, and tapeworms can be found in all types of water from mountain lakes and reservoirs to lowland rivers, streams and ponds.

A white worm To the naked eye, tapeworms look like white tapes, ranging in length from 2cm (¾in) to 1m (3ft), depending on the host and the species and age of the parasite. On closer inspection, three distinct regions of the adult tapeworm can be recognised. At the front of the worm is the small scolex or head region, bearing suckers or shallow depressions which attach the worm to the intestinal wall of the fish. Behind the scolex is a short neck. The third region of the worm, the strobila, is a series of discrete but connected segments called proglottids. Each proglottid contains a complete set of male and female reproductive organs, and the strobila grows as new proglottids develop out of the neck region, so that the most posterior is the oldest. The chain of proglottids may number several hundred. (One small group of tapeworms does not form proglottids, and has only one set of reproductive organs.)

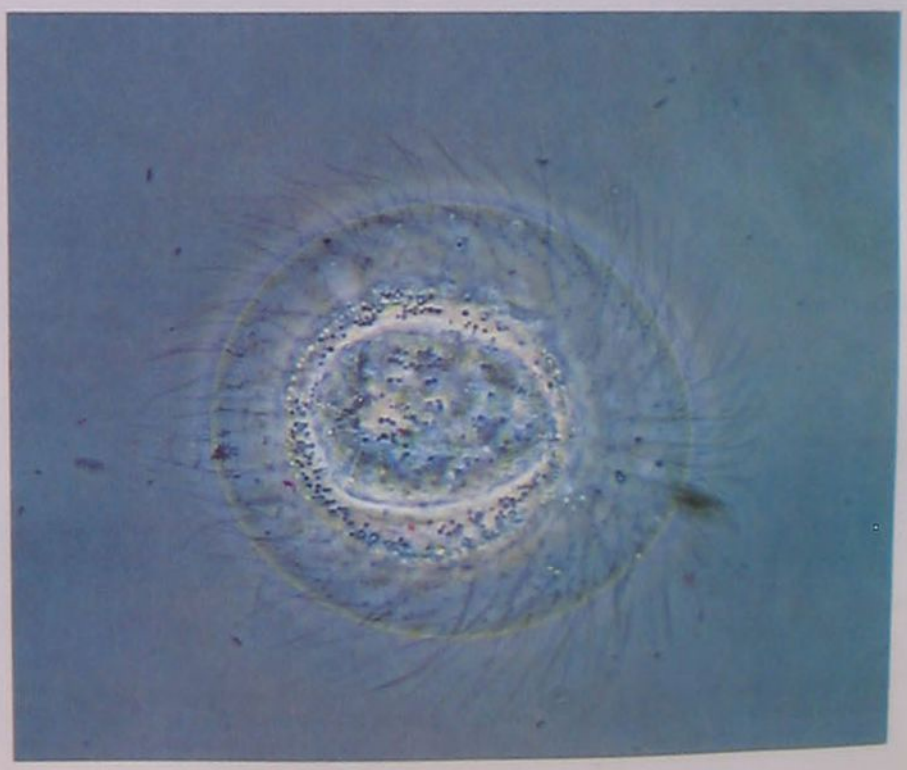
Living in All tapeworms have complicated life cycles, and fish can serve as definitive, or final, hosts, in which the parasite becomes adult and sexually mature, or as intermediate hosts, in which the parasite is in a developing larval stage. Those tapeworms using fish as definitive hosts are always found in the intestine, and numbers can range from 1-100 per fish.

If another individual is present in the host,



This species grows to a length of about 30cm (12in), and lives in trout and salmon.

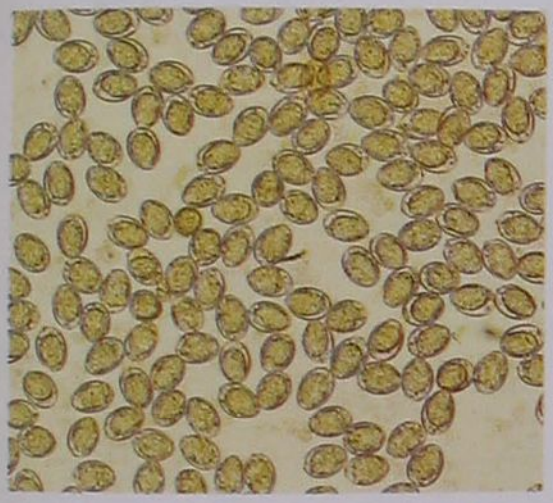
The adult worm of *Bothriocephalus acheilognathi* (above left) may produce some 7000 eggs. These are shown, greatly magnified, on the right, while a ciliated larva of the species is shown below.



cross-fertilisation may take place, but if not, tapeworms are self-fertilising. All proglottids produce eggs around the same time, and these are released through a pore and pass out of the fish in its faeces. After breeding, the proglottids degenerate and the whole tapeworm dies, its life-cycle completed.

An excess of eggs Tapeworms may undergo up to three larval stages, and occupy up to three hosts of different species in succession. For the cycle to be completed, all the host species must be present at the right time. At each stage, from egg to the last larval stage, the probability of infecting the host is low, and so mortality rates are high. Like colonizer species, therefore, tapeworms have high reproductive powers and efficient dispersal mechanisms. The flow of rivers and the movement of water in lakes help to disperse the vast numbers of eggs and ciliated larvae.

An adult *Bothriocephalus* tapeworm, for example, may produce 7000 eggs, but only 0.02% of these may reach the next host–possibly resulting in only one larva. Each *Triaenophorus* adult has to produce around



one and three-quarter million eggs in its life to replace one adult. It has been calculated that a single lake may contain 100,000 larvae of *Diphyllobothrium* tapeworms, but only 200-400 adults.

Looking at larvae If the fish is an intermediate host, the larval tapeworms live in the body cavity. In earlier stages, for example in the copepod, the larva is a small creature known as a procercoid. In the fish stages it grows into a longer, more worm-like form known as a plerocercoid larva. Plerocercoid larvae are white and opaque, and although most are only 2 or 3cm (1in) long, some may reach almost 1m (3ft).

Larvae often accumulate as fish age, so numbers may be high. A fish may harbour several hundred *Diphyllobothrium* larvae, or up to 50 larvae of *Ligula*. The combined weight of the parasitic larvae may even exceed a quarter of the weight of the fish itself. Once in the definitive host, the larva metamorphoses into an adult tapeworm.

Tapeworm distribution The distribution of a species of tapeworm is dependent on the distribution of all its hosts. In Britain, species of *Eubothrium* may be found wherever there are salmon and trout, whereas *Ligula* is more common in lowland lakes and rivers where plankton, coarse fish such as roach, and birds are abundant.

Effects on the host Adult tapeworms may cause local inflammation in the host, but are not seriously harmful, apart from *Bothriocephalus acheilognathi*, which may debilitate and kill young carp.

Ligula, however, causes its host to become sterile, and in addition it affects the shape, stamina and behaviour of the fish in such a way as to make it conspicuous to bird predators, so helping to complete its life cycle, since the bird is its definitive host.

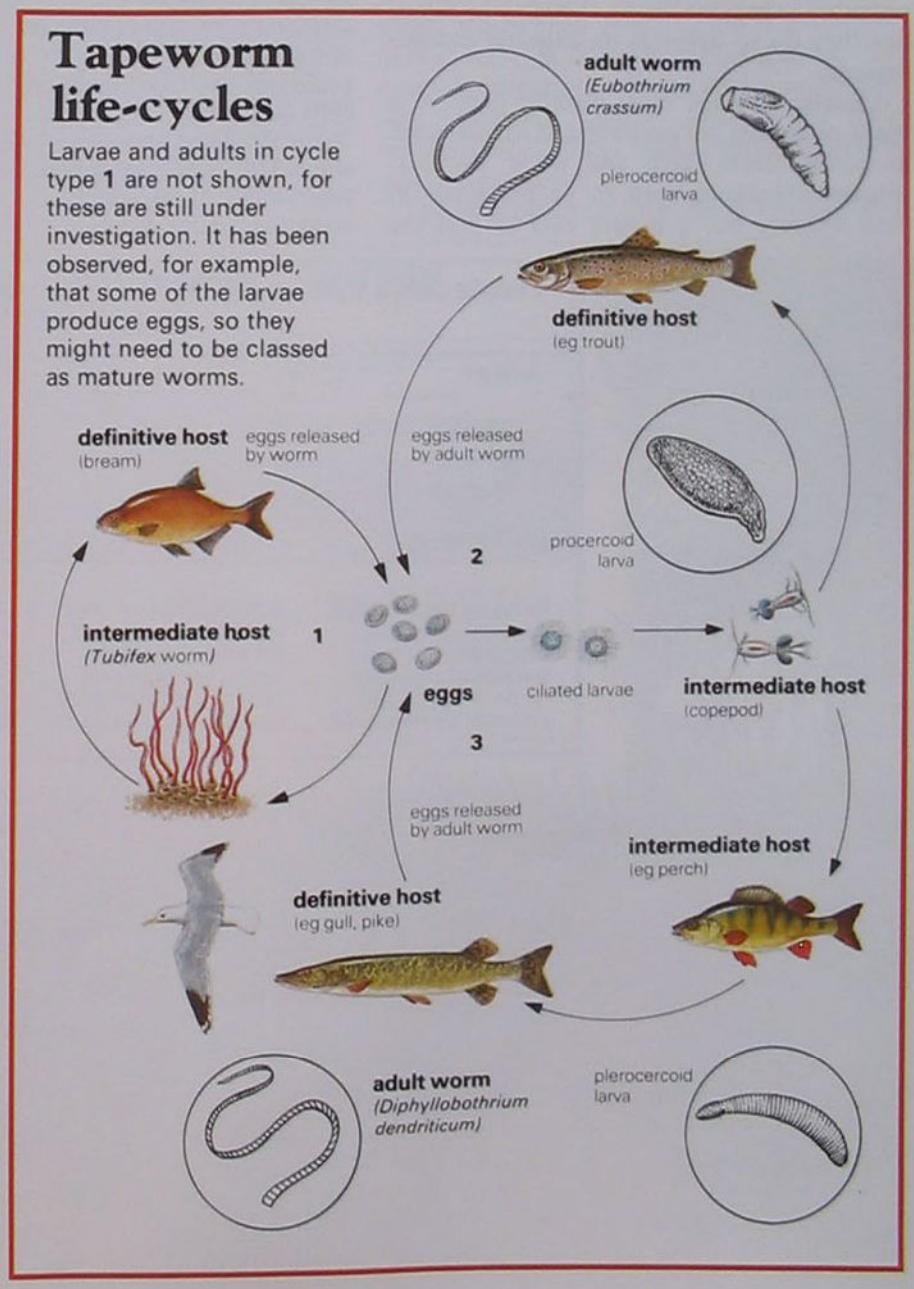
Only *Bothriocephalus acheilognathi* is a serious pest in fish farms in Britain, and no British species infect man. The only fish tapeworm to do so is *Diphyllobothrium latum*, the broad tapeworm of man, and this is believed to be extinct in Britain. The thought of fish tapeworms is thus far worse than the reality.

Life-cycles

The life-cycles of all fish tapeworms begin from an egg, which is shed in the water. In group **1**, eggs are eaten by a *Tubifex* worm, inside which the larva develops, and this in turn is eaten by a fish. In groups **2** and **3** the egg hatches to produce a ciliated larva, which lives for one or two days and then dies unless eaten by a suitable species of copepod. When an infected copepod is eaten by a fish, some species (**2**) grow and mature in the fish, but others (**3**) undergo a second larval stage in the fish, while they await ingestion by the definitive host, which must, of course, be there at the right time.

Tapeworm life-cycles

Larvae and adults in cycle type **1** are not shown, for these are still under investigation. It has been observed, for example, that some of the larvae produce eggs, so they might need to be classed as mature worms.



FOSSILS: THE KEY TO THE PAST

Laid down in rocks, perhaps hundreds of millions of years ago, fossils provide a glimpse of the plants and animals that once inhabited the earth.

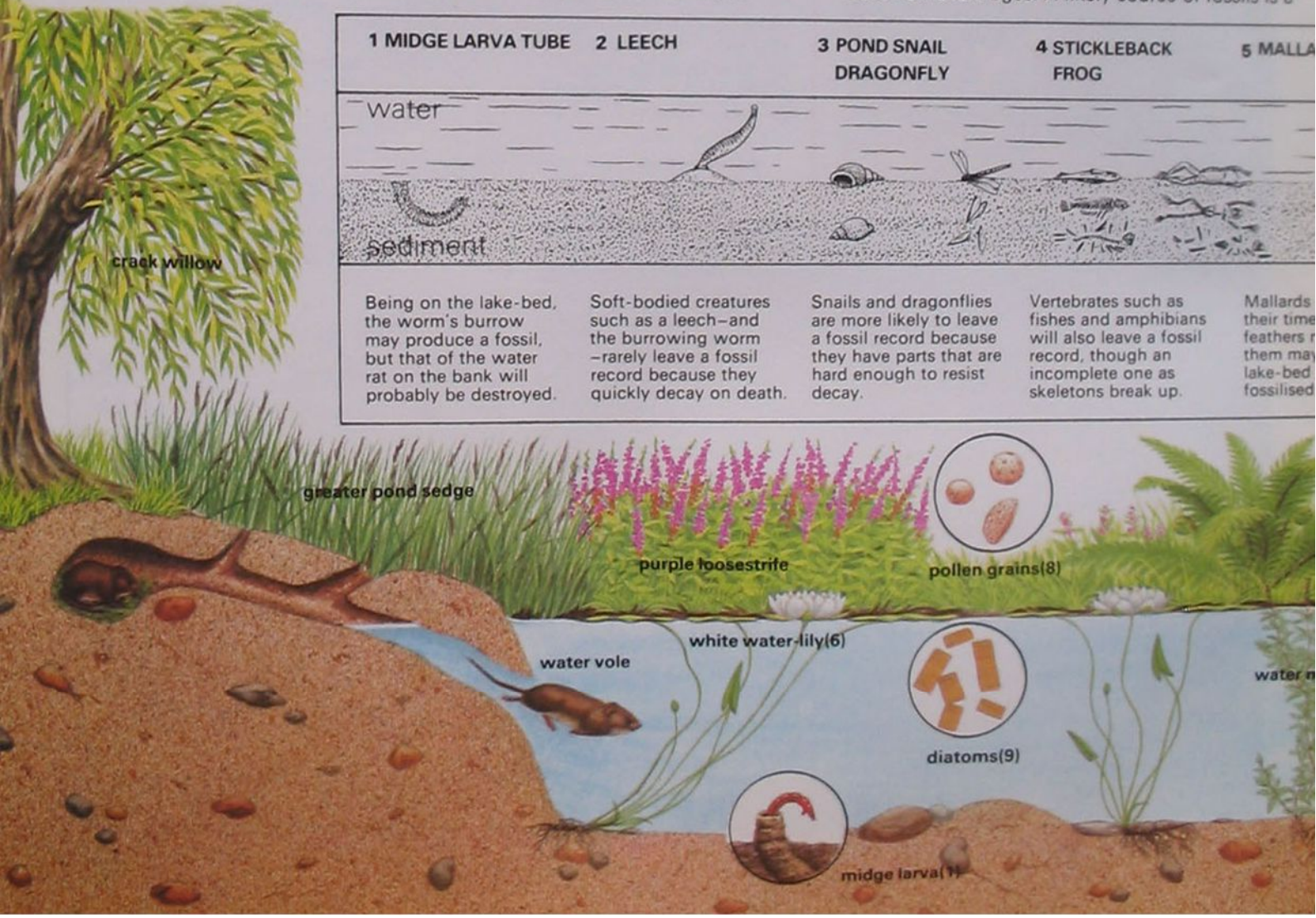
Fossils have been forming ever since life first began more than 3000 million years ago. Many plants and animals shed parts of themselves during their lives–the milk teeth of a mammal, the cast-off shell of a crab or the seeds of a plant are just a few familiar examples. These, plus of course the plant or animal itself when it dies, all have the potential to become fossils, though whether or not they do so depends on external circumstances.

Usually only the more durable parts of a plant or animal are preserved as fossils–such as bones, teeth, shells and wood. Smaller, simpler organisms tend to be preserved in their entirety but it is very rare to find the

Above: A fossilised ammonite–an extinct relative of the octopus and squid–exposed by crumbling cliffs along the Dorset coast. The fossil dates back to about 150 million years ago, when much of the south coast was under water.

Fossils of

It is sometimes tempting to think of fossils only in terms of plants and animals that were alive millions of years ago, without realising that the plants and animals of today will become the fossils of future ages. A likely source of fossils is a



Above: Fossilised ammonites. Notice how some fossils are casts of the original animal while others show only the impression, being formed as a mould around it. One ammonite may produce both types of fossil, called part and counterpart.

he future

freshwater lake where, as the wildlife dies and settles to the bottom, both they and the signs of their activities will become slowly buried in the sediment of the lake-bed and form into fossils –given enough time.

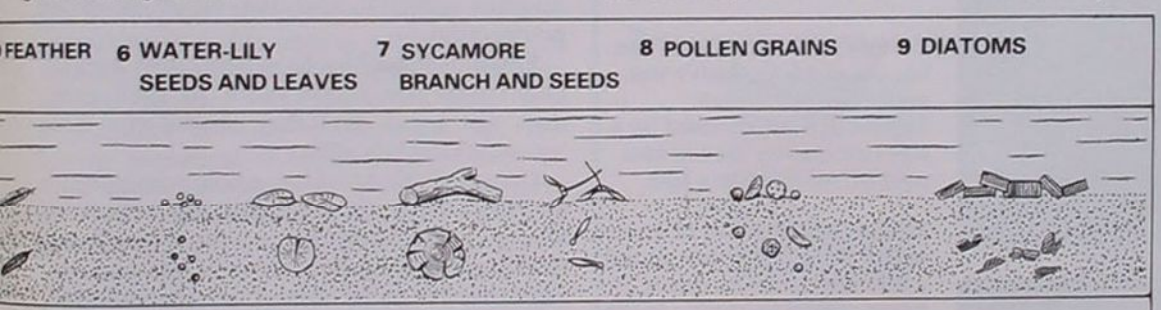
whole skeleton of a large animal or a whole tree with its branches and leaves still intact. In most cases just isolated bones or teeth (sometimes still set in a jaw), pieces of wood or single leaves are found. The softer tissues and more delicate organs, like skin, flesh, flowers and so on, normally decay very rapidly in air before they can be covered in sediment and hence preserved.

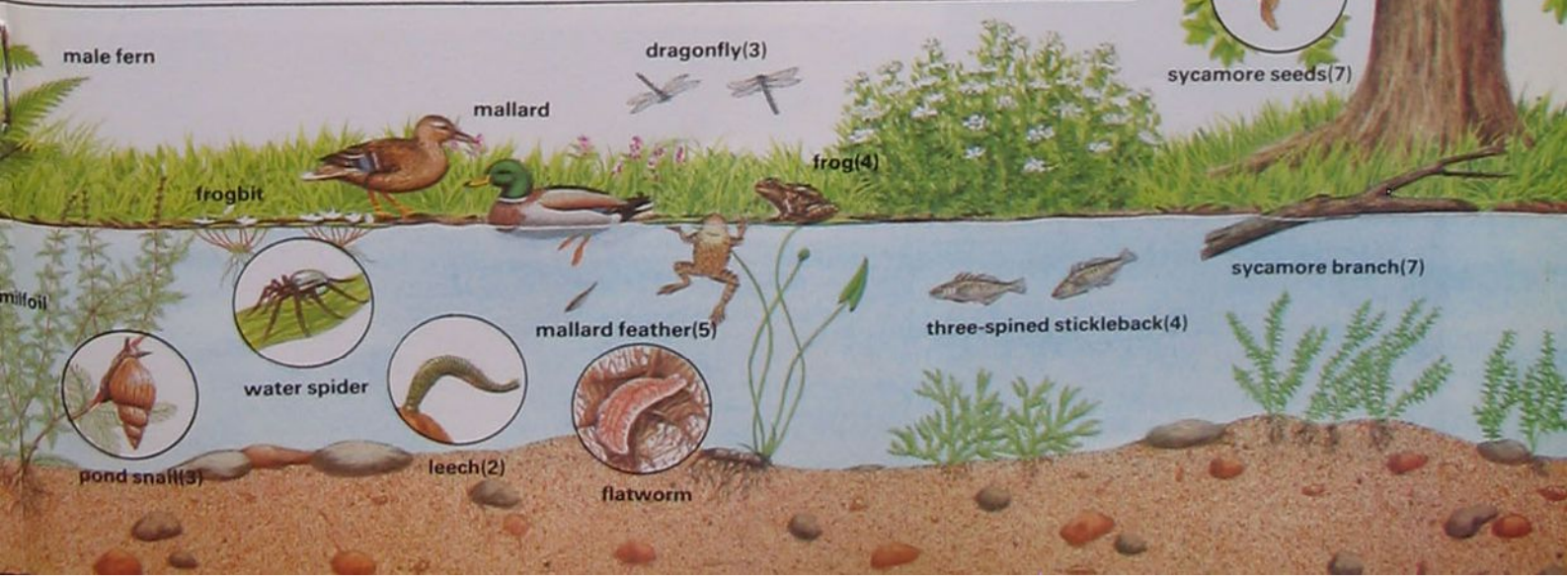
Occasionally, however, these softer structures are preserved because of unusual circumstances. Entire frozen mammoths have been discovered, as have flowers which have been turned into charcoal, having been caught in an ancient forest fire. A variety of beautiful fossilised insects and flowers have been preserved whole in amber, a substance formed from resins exuded by trees.

How fossils are formed Most fossils are formed by organisms being engulfed in sediment before they can decay. In many cases plants and animals are unlikely to become buried in sediment and are therefore unlikely to fossilise except in catastrophic circumstances such as a flood, storm or volcanic eruption. Some, however, live in environments where their preservation is extremely likely, even in normal circumstances, for example animals that live in the sea or burrow into sediments. Others, such as the reef-building corals, build what is tantamount to a ready-made fossil.

Once the potential fossil has been entombed

FEATHER	6 WATER-LILY SEEDS AND LEAVES	7 SYCAMORE BRANCH AND SEEDS	8 POLLEN GRAINS	9 DIATOMS
end part of shore, but oulted by settle on the nd become	Being herbaceous, parts of the water-lily will decay, but its leaves and seeds may be preserved in the sediment and fossilise.	Woody plants such as sycamore are more likely to fossilise, especially the seeds–and a branch if it breaks off and sinks.	Pollen grains of both woody and herbaceous plants have protective outer coats, so they are likely to survive and fossilise.	Diatoms, which are single-celled algae, have hard walls and, on sinking to the lake-bed as detritus, many will fossilise.





Above: The fossilised body and tail of a trilobite, a primitive arthropod now commonly found in fossilised form. You are much more likely to come across parts of an animal (or plant) as fossils than a whole specimen.

Left: A fossilised frond of a fern, discovered in Somerset. It dates from the Carboniferous era around 300 million years ago, when many of our coalfields were being laid down.

Bottom left: A fossilised tree, known as McCulloch's tree, on the island of Mull, Scotland. It was formed by a tree being entombed in lava over 60 million years ago.

Below: The skeleton of a rabbit accidentally uncovered a few years after its death. If it had remained hidden in the soil it would probably have become fossilised over the course of time. Notice how the skeleton has already begun to break up, simulating older fossils.

by sediment it may still be at risk if the chemical conditions in the sediment change. For example, shells, which are made of calcium carbonate, survive so long as the conditions in the sediment remain alkaline. But if, for some reason, acidic waters start to percolate through to the shell it will be attacked and gradually dissolved away. However, although the shell is destroyed it may still leave a fossil record. This can happen by a process known as infilling. Sediment gradually seeps into the interior of the shell and, as the sediment hardens into rock, it forms an internal mould of the shell, even though the shell itself has been destroyed. Similarly, the sediment surrounding the shell can also form an external mould of the outer shell surface. Thus a fossil may look as though it contains material from the original organism, yet be nothing but pure rock.

This phenomenon is not just restricted to shells. Petrified wood is another example of a fossil that contains no original organic material. The first stage towards petrifaction is known as permineralisation, where mineral-rich waters seep into, say, a piece of wood. As the minerals crystallise out they effectively form a mould of each cell but the cell walls themselves remain intact. So a permineralised fossil still contains some original material.

If, however, the cell walls subsequently decay and are replaced (cast) by more minerals, then the fossil has lost all of its original material and the result is called petrifaction.

Fossil communities In general, just because two fossils are found close to each other does not mean that they shared the same 'ecosystem' when alive.

Occasionally, however, whole communities and their life-styles are preserved in the fossil record, particularly in the case of sediment-dwelling communities–those plants and animals that live on or burrow into the sediment.

An example is the fossils found in peat. In some ancient marshes and swamps, plants and animals did not decay when they died but instead accumulated in the sediment. Over millions of years this organic-rich sediment was gradually converted into peat and the fossils

contained in it authentically reflect the original community. The Rhynie chart in north-east Scotland is an example of a very ancient peat community; it has been dated to be about 380 million years old. Many more modern communities have been preserved in peat over the last 10,000 years.

Piecing together the past Most fossils found today are merely fragments of plants or animals–rarely of entire organisms–and the job of piecing together these fragments to discover the kinds of life that used to inhabit the earth is a daunting task. Often it is only possible to say that a particular fossil is 'a bird bone' or 'a piece of wood', without being able to say what type of bird or what type of tree. It may be that the particular bird bone is similar in different species or, in the case of wood, that the fossil has been poorly preserved.

Nevertheless, years of painstaking work have enabled palaeontologists (scientists who study fossils and the past) to piece together the jigsaw and discover what life was like millions of years ago. Fossil fragments of both plants and animals can often be compared with more complete fossils or with living organisms, and thus be identified. In the case of plant fossils the structure of the cells can often be examined and deductions can be made on the basis of certain fossils being repeatedly found close together (this is much less reliable a method for animals because of their mobility).

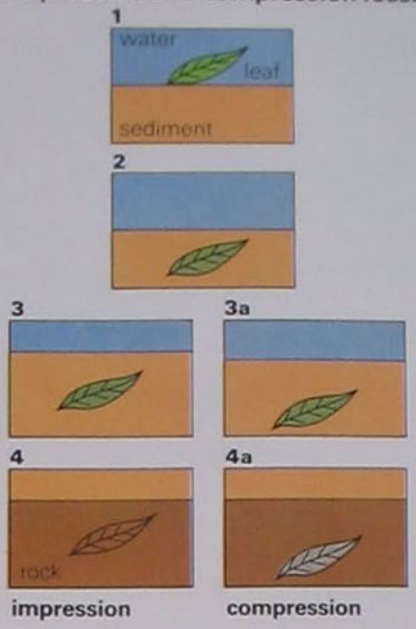
From a fossil it is possible to build up not just a picture of the plant or animal but also something of its life-style or habit. Combined with what geology teaches us about the past, we can envisage what the world must have looked like millions of years ago. By following sequences of fossils through time we learn how, in some cases, organisms have evolved in time and how our modern plants and animals come to be as they are today.

Dating fossils

How do scientists know that fossils are millions–sometimes hundreds of millions–of years old? In some cases an absolute date can be put on rocks, and the fossils therein, by a process called radioactive dating. This takes advantage of the fact that some rocks, when they are first formed, contain small amounts of the radioactive element; uranium-238. This is unstable and slowly decays at a fixed rate to form lead. By comparing the amounts of lead and uranium-238 in a sample of rock, scientists can discover its age with reasonable accuracy. Other radioactive elements can be used to date rocks in the same way.
Many sedimentary rocks, however, do not contain minerals suitable for radioactive dating. These have to be dated by a process called relative dating, in which the rocks are correlated with other rocks that have been dated absolutely, for example, by comparing changes in the earth's magnetic field 'locked' within the rocks.

Fossil formation

Impression and compression fossils

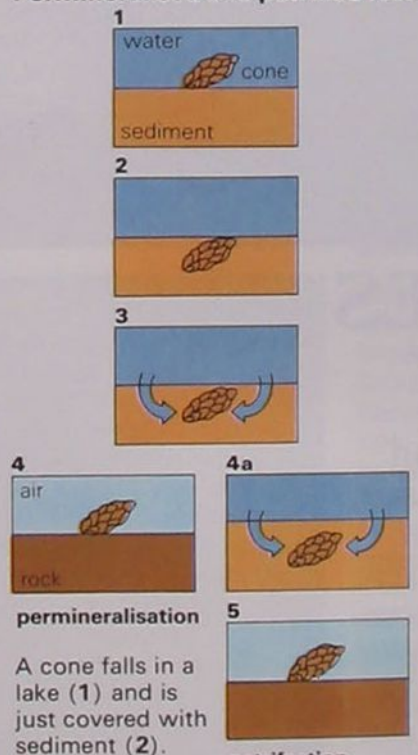


A leaf sinks to the bottom of a lake (**1**) and is covered with sediment (**2**). If it stays close to the surface (**3**) it is oxidized by the water and decays, leaving just an impression in the rocks (**4**). If buried deeply (**3a**) it survives and is compressed inside the rock (**4a**).

Cast and mould fossils

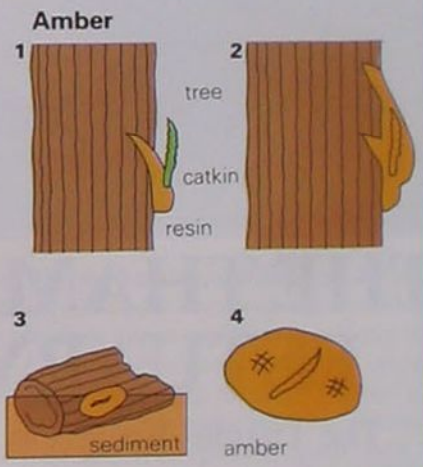
A gastropod on the sea-bed (**1**) dies, leaving just the shell (**2**) which is buried and infilled with sediment (**3**). In acid conditions the shell is destroyed (**4**) leaving a mould and cast fossil (**5**).

Permineralised and petrified fossils



A cone falls in a lake (**1**) and is just covered with sediment (**2**). Waters rich in minerals seep in and crystallise (**3**), giving a permineralised fossil (**4**). If all organic matter decays, more water seeps in (**4a**), resulting in petrifaction (**5**).

Amber



Amber fossils are formed in quite a different way from the other examples. Some resin oozes out of a tree trunk and, before it hardens, a catkin lands on it and becomes stuck (**1**). More resin from higher up the tree oozes out and covers the catkin (**2**). The resin hardens and the catkin is trapped inside. The tree subsequently dies and the trunk is buried in sediment (**3**). The hard resin is fossilized into amber and the catkin inside is preserved from decay (**4**).

THE THAMES ESTUARY

The Thames Estuary is an area of paradoxes–great parts of Thames side are taken up with industrial complexes and housing estates, yet close by are marshes and wild open spaces rich in wildlife.

The mouth of the River Thames is a typical trumpet-shaped estuary, widening the further it gets towards the sea. Its limits are difficult to define, particularly towards the sea, for the accidents of history–and prehistory–have produced a series of boundaries. Historically, the most interesting boundary is marked by two 'stones': the Crowstone on the Essex shore between Leigh-on-Sea and Southend-on-Sea, and the London Stone, near Yantlet Creek on the Isle of Grain on the Kent shore. This Crowstone-Yantlet line, at a region where the river is nearly four miles wide at high tide–but only half that at low tide due to the enormous sand banks on either shore–is the ancient seaward limit of the jurisdiction of the Corporation of the City of London which, from medieval times through to the last century, controlled shipping, fisheries and public health on the river.

The ancient Thames However, the prehistory of the river had a more profound effect on the wildlife of the estuary. Up to and shortly after the last Ice Age the Thames was a tributary of the River Rhine and flowed north-eastwards across the bed of the southern North Sea, presumably to flow into the deeper northern North Sea. At this time the southern parts of the North Sea were covered

Above: Moored boats on the Medway. The River Medway flows into the Thames Estuary at Sheerness.

Right: Common oysters. In the deeper waters of the Estuary, large numbers of oysters occur. Many of the oysters supplied to the London markets come from here–especially the Pyefleet oysters from the Colne mouth. The Essex oyster beds were the site of the accidental introduction of the slipper limpet, a North American mollusc which, by its sheer numbers, drowns out and competes with the more valuable oysters. It is now found along most of the coast of England.

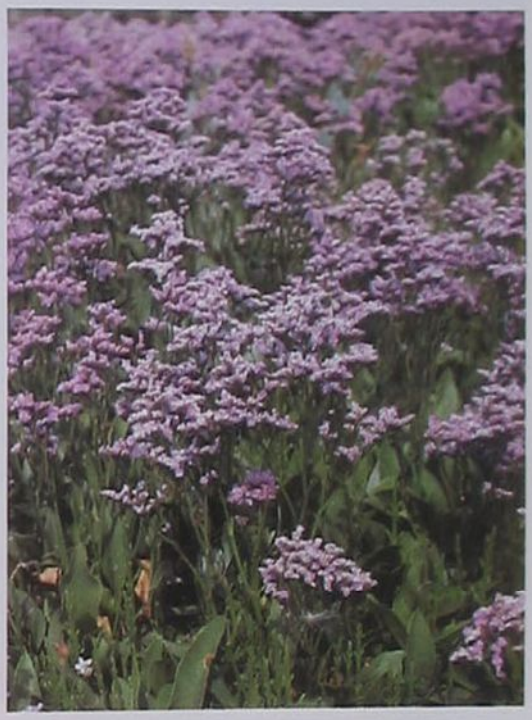
with wooded marshy ground interspersed with river channels and lakes. However, in the immediately post-glacial period the impounded water of the 'North Sea' lake broke through the Straits of Dover and Britain became an island. The Thames, no longer a tributary of the Rhine, became isolated and, due to rising sea levels and general depression of the land in this part of England, continued to diminish in size.

Thus the estuaries of the River Medway on the Kent coast, and the Crouch, Blackwater and Colne on the Essex coast–which today look like river estuaries in their own right–are no more than feeders of the greater Thames estuary, which can be said to extend from the North Foreland on the Kent coast to Harwich at the northern tip of Essex, and encompass the entire Essex coast.

A glimpse of green Downstream of the centre of London, and past the great sewage treatment plants of Beckton and Crossness, open spaces along the river show glimpses of green beyond the river wall around Dartford, near Cliffe, and on the Essex coast below Tilbury. Apart from the industrial horror of Thames Haven and western Canvey Island, and the Medway at the Isle of Grain, the estuary presents a natural aspect, with fields and even marshes, and sand and mud flats on the river side of the sea wall. The first glimpses of sea marsh and saltings can be seen at Canvey Point and on the Leigh Marshes. The Medway flows into the estuary at Sheerness, and from thence on the Kent shore the coast runs uninterrupted, with sand and shingle shores and the huge expanse of the Kentish flats to seaward, none of it deeper than 6m (20ft) until Margate and the North Foreland are reached.

The Essex coastline is as convoluted as the Kentish is smooth. From Southend-on-Sea the shoreline turns north-eastwards along the

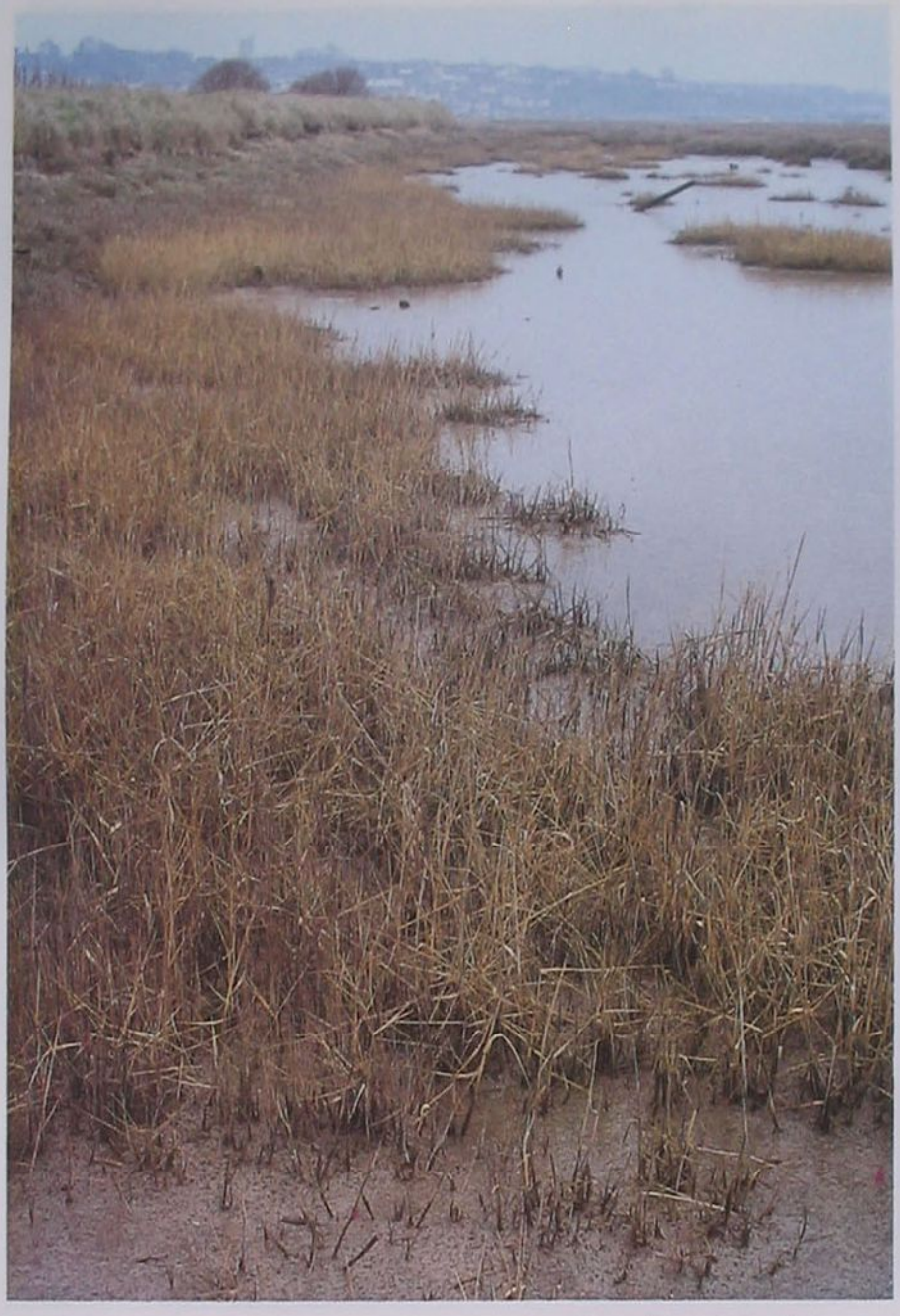
Above: Great flights of dunlin can be seen wheeling in the skies over the Thames' estuarine saltmarshes. They come to probe the mud for invertebrates and are often accompanied by turnstones, ringed plovers and oystercatchers.



Right: Common sea lavender –found in abundance on the Thames saltmarshes. It can sometimes be seen covered with a fine web and a mass of ground lackey moth caterpillars. These caterpillars live in a community on the top of the plant and are apparently immune to occasional immersion in salt water from the sea.

secretive Maplin Sands and Foulness, with the tiny River Crouch forming its northern border. It then turns northwards along the Dengie Flats to Bradwell, with its nature reserve and dominating nuclear power station. The River Blackwater joins the Thames estuary here as, too, on the north side of Mersea Island, does the Colne. From thence at first eastwards and then curving north, comes the familiar Essex coast of Colne Point, Clacton, Walton-on-the-Naze, the Naze itself and the little-known Walton backwaters with their secret and private islands, and finally Harwich on the distant horizon.

Much of the land shows the hand of man. Even the farmlands have to be protected by massive sea walls, for this part of England is slowly and steadily sinking into the sea, and the fields must be drained by ditches and channels. Too many parts of the coastline have produced ugly rashes of caravans and chalets for summer use, and the quiet waters attract sailcraft and offensive powered boats.

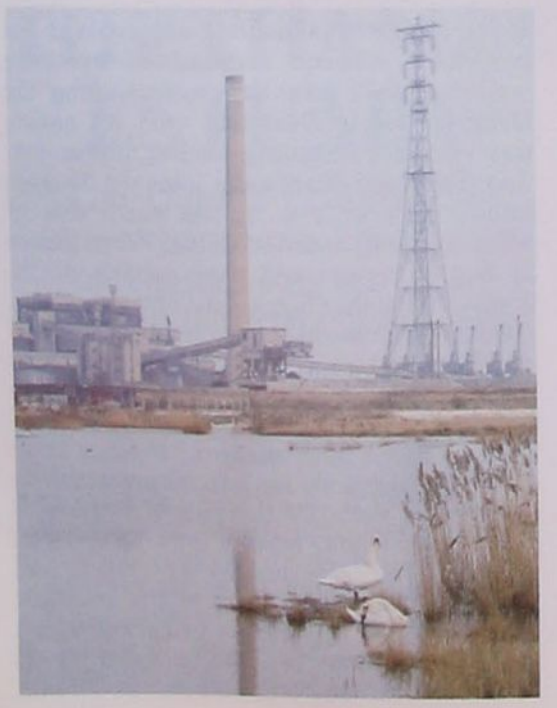


The sewage sludge from London is dumped in the mouth of the Thames, luckily to be swept north-eastwards into the North Sea. The strong currents of the outer estuary have meant that for a century now London's sewage sludge has been jettisoned into either the Black Deep or the Barrow Deep–which lie seaward of Foulness–without (so far as can be detected) any harm to the environment. Yet, despite all this, there is abundant wildlife.

The saltings Many of the wilder borders of the estuary are fringed with saltings: areas of marshland flooded by the sea at high spring tides in spring and autumn but dry, or comparatively so, the rest of the year. Yet twice a day the tide comes quietly sneaking in to fill the deep muddy channels that snake through the saltings, cutting them a little deeper here, depositing jetsam there, and bringing brief activity to the animals living in the mud.

On an early summer's day the saltings are places of incredible beauty and calm. Fine sea meadow grass forms the main vegetation while on the higher saltings sea lavender grows in dense clumps of purple-blue flowers. Everywhere on these saltings the pale green spikes of marsh samphire stand erect, the older plants tough and branched, the young tips and shoots tender and succulent.

The rewards of these sea marshes can be great. Redshank and curlew are common on the edges of the saltings, great flights of dunlin wheel away against the grey sky, and turnstones probe the mud, together with ringed plover and oystercatcher. The evening flights of duck attract wildfowlers on the quieter marshes, and great flights of Brent geese come in from the sea to graze warily on the newly sprouted corn in the fields, not infrequently leaving huge barren patches. Almost anywhere in the estuary shelducks can be seen in winter, although in the summer they can be

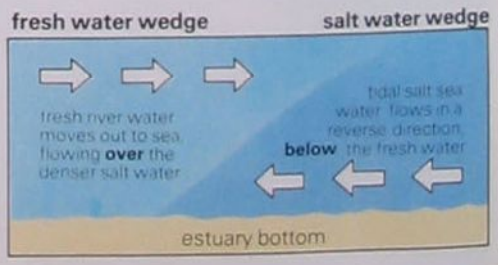


Above: The saltmarshes can be frightening on a winter's day when the wind drives in uninterrupted from the North Sea and a cold light makes each dark channel a menacing chasm. And, indeed, they can be dangerous. It is too easy for inexperienced people to find themselves cut off from the sea wall by a water-filled maze of deep channels, and the knowledge that you could soon be knee-deep in water does not contribute to peace of mind.

Left: Wildlife in an industrial wasteland–mute swans and common reeds on a pit near West Thurrock Power Station.

Where fresh water meets salt

The amount of salt in the water varies with the state of the tide and with upland flow (fresh water coming downstream). As fresh water is less dense than sea water, the fresh water forms a wedge and flows downstream on the surface of the sea water which, also wedge-like, flows upstream. But the course of the tideway is so irregular, with 25 sharp bends between Teddington and the sea, that fresh and sea water become thoroughly mixed and the salt content gradually increases towards the sea.



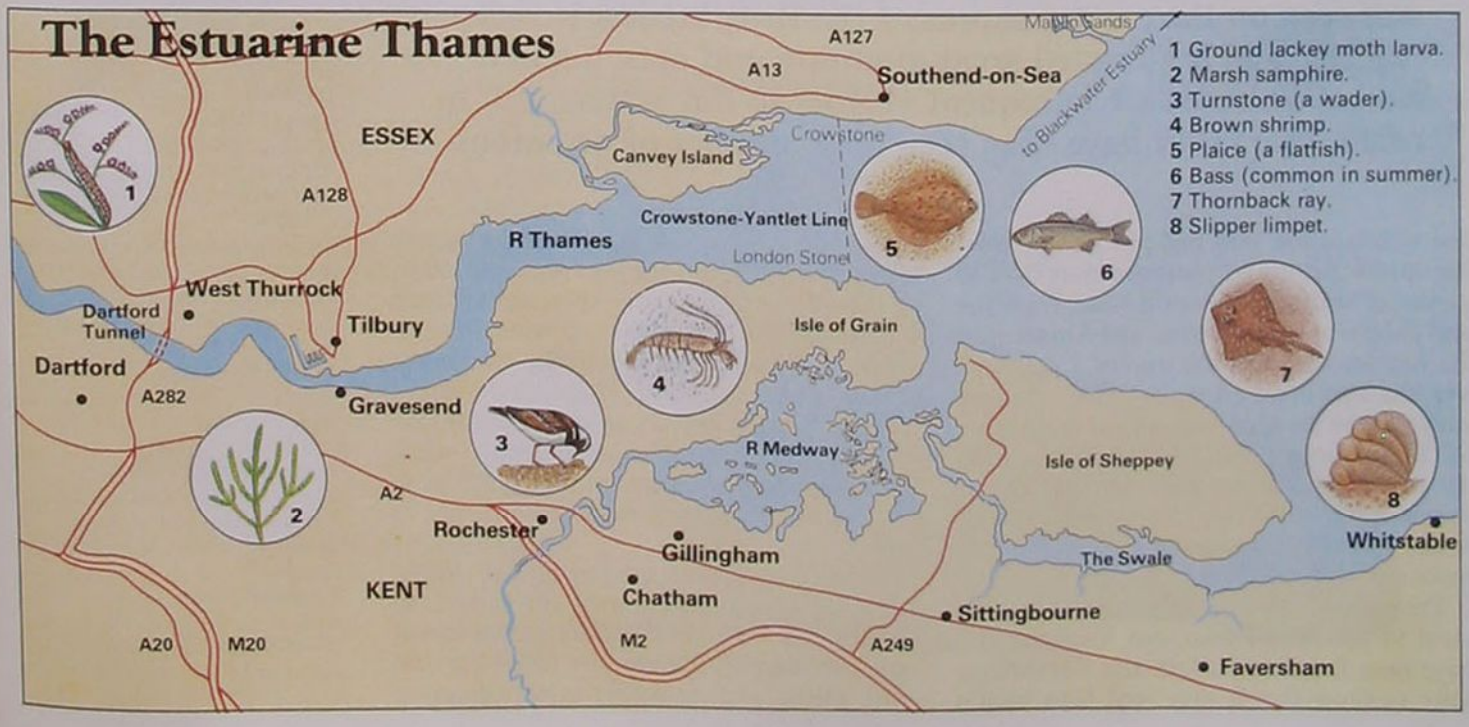
found only on the quieter stretches. However, many of these waders and ducks make their way up the Thames in winter and can be seen on the foreshore resting, or feeding on hidden invertebrates in the mud against a backdrop of such electricity generating stations as West Thurrock and Littlebrook.

Other estuary animals The Thames is a typical estuary as regards the animals found there, with a relatively impoverished fauna in terms of numbers of species. However, these species are often represented by millions of specimens. Fishes are a good example of this. There are probably only 50 kinds which are at all common, and fewer than 20 are abundant, yet it is possible to catch thousands in a short space of time using appropriate methods. Young herring are abundant in winter and early spring in the Thames mouth, as are sprats, which tend to be present and leave earlier than the herring. The whitebait (young) stage of both forms is important food for terns, both during the breeding season on Foulness and near Colne Point, and throughout the river estuary during the rest of the year.

The sand banks (often rather muddy, depending on local currents), are important nursery grounds for flatfishes; huge numbers of dabs, plaice and sole congregate for the rich feeding in the sheltered tidal waters of Maplin Sands and the Blyth Sands. Flounders, too, are abundant all the way up to Teddington. Young whiting also flourish, especially in late autumn and early winter. Smelt and eels are abundant as well, being typically estuarine fishes. Larger fishes appear in good numbers seasonally; cod, for instance, migrate southwards in winter and become common all along the outer estuary. In the warmer seasons they are replaced by large numbers of bass, grey mullet, thornback rays and two sharks –the smooth hound and the tope.

The thornback and the less common sting ray and the two sharks are attracted by the rich invertebrate fauna of the estuary. Brown shrimps abound in huge numbers on the sandy and muddy bottoms, pink shrimps and prawns are found in numbers in the deeper water where the bottom is hard, and the sand banks all along the estuary abound with cockles, which form the major food of oystercatchers and sting rays. But perhaps the most typical animal of the estuary is the shore crab. Because of its abundance it is an important food resource for many of the Thames estuary fishes and birds, and it is an equally important predator on smaller animals, as well as being a scavenger.

Above: A view of the Blackwater Estuary, which joins the Thames estuary at Bradwell. The River Blackwater has its own distinctive race of herrings, characterised by their small size and the number of vertebrae and scales (these last detectable only from statistical analysis of large samples). They spawn in April on the Colne Bar, shedding their eggs on the clear gravel in this area. In their first year they form schools in the Colne and Blackwater mouths.



Above: Although the walrus is a rare visitor to the British Isles, it is unmistakable for its massive size and very long tusks.

WALLY, AND OTHER WALRUS VISITORS

During the late summer and autumn of 1981 an unusual visitor was seen on the eastern shores of the British Isles. It was a walrus, and it attracted great attention and even a name–Wally. Walruses are infrequent visitors to our waters, but in recent years they have been seen on a number of occasions.

The walrus is the 'odd one out' in the order Pinnipedia. Altogether there are more than 30 species of seals spread world-wide, from the cold polar seas of both Arctic and Antarctic to the warmer waters of the tropics. Compared with the two main groups of seals–the true seals and the sea-lions–the walrus looks most like the sea-lions in that it is able to raise itself up on its flippers to walk on land. Most people, if they came face to face with a walrus, would probably recognise it by its pendulous tusks and stiff moustache.

The walrus has probably never been resident in the British Isles, but fossil remains have been found in Suffolk and Cambridgeshire to show that it may well have been a fairly regular visitor during one of the periods when much of the British Isles was covered by ice. Some archaeological sites in northern Britain have yielded walrus remains, but this does not prove that it was resident. On the isle of Lewis in the Outer Hebrides a set of chessmen was found at an early burial site. The chessmen were fashioned from walrus ivory, but archaeologists are in dispute as to whether the handiwork was done in Lewis or outside Britain.

Early days Walrus hunting in the Arctic began on a large scale during the early 17th century, but the fortunes of the walrus varied very considerably during the following 200 years. Often whalers would turn to hunting

WALRUS
(*Odobenus rosmarus*)
Length Male 3.2m (10½ft), female 2.5m (8¼ft).
Weight Male 1200kg (2645lb), female 700kg (1543lb).
Colour Generally cinnamon-brown all over; older adults may be paler, especially if they have been immersed in cold water for some time.
Breeding season Throughout April-June.
No of young One–twins very rare.
Food Shellfish, especially clams, mussels, cockles. Occasionally small seals, cetaceans, probably as carrion.
Predators Man, killer whales, polar bears.
Distribution Occasional visitor to British waters.

walrus when whales became scarce. Trading in walrus ivory and hides caused the slaughter of many thousands of walrus, and only during the 20th century has any control been exercised. The value of the walrus to hunters lies in the ivory of the tusks: they were initially used for harpoon heads and toggles, but more recently for carving. The meat is said to be good to eat–at least the Eskimos think so–and the hide has been used for sledge harnesses, thongs, whips and even billiard cue tips. Since the 1950s there has been some control of hunting in most areas, although native peoples are in most cases still allowed to hunt walrus for food and clothing. It is possible that walruses are making a comeback from the decline of the past century, and it may be that the recent increase in walrus sightings is connected with a recovery of the populations in Spitsbergen and Novaya Zemlaya.

Three populations There are three main populations of walrus–the Atlantic, Pacific and Leptev populations. The latter is small in numbers and only found off the remote northern coasts of Russia. The Pacific walrus is found in the Bering Sea and around the north-western extremities of Canada. The Atlantic walrus is found around northern Greenland, Spitsbergen, Novaya Zemlaya, and in northern Canada around Hudson Bay and Baffin Island. It is most likely that animals from either Spitsbergen or Novaya Zemlaya are those that occasionally travel to British waters. The Atlantic walrus is smaller than its Pacific relative, but all the descriptions and figures here refer to the Atlantic form.

In recent years walruses have been seen around the North Sea on a number of occasions, and sightings in the last ten years greatly out-number all of those since the turn of the century. It is not known why this should be so: maybe the more frequent wanderings of this Arctic animal are the first signs of a colder climate to come.

The Atlantic walrus This walrus lives in cold northern waters and is usually associated with drifting ice. Males can grow up to a maximum length of about 3.2m (10½ft) and weigh about 1200kg (2645lb), which makes the walrus the second largest pinniped after the elephant seal. Females are rather smaller at about 2.5m (about 8ft) and weigh around 700kg (1543lb). They give birth to one large pup which weighs 50kg (110lb) at birth and is about 120cm (47in) in length. Twins are very rare.

The young are born in summer from late April to June and grow very rapidly. In spite of their rapid growth the young may stay with their mothers for up to two years and may be suckled for much of this time. Because of this extended nursing period the females cannot give birth more frequently than once every two years, and the interval may be greater than this.

Both males and females have tusks, although those of the male are longer and straighter. Walrus feed on shellfish to a great extent, with mussels, clams and cockles also forming an important part of their diet. They grub up their food from sandy bottoms using their strong lips and long tusks. The shells are broken up and rejected while the soft fleshy parts are sucked in. There are a few records of walruses having been found with seal and narwhal remains in their stomachs, but it is thought most likely that these have been taken as carrion rather than as living prey. Walrus are much less adept at diving than many other seals, their underwater excursions lasting about five minutes and rarely more than ten, while they are reported to dive no deeper than about 80m (590ft).

One unusual feature found in walrus but in no other pinnipeds is the pharyngeal pouches. These are air sacs, sited at the sides of the throat and extending around the neck. They are only found in males, and are developed in

Above: Wally, a young male walrus that came to the British Isles in 1981. He was first seen in Shetland in late July on the Island of Yell, close to the ferry terminal at Gutcher. He then disappeared, only to reappear further south in the area of the Moray Firth and at Crovie in Banffshire. The journey from Shetland had taken almost a month. From north-east Scotland Wally continued on his way south and next appeared on the beach at Skegness in mid-September. Staff from Skegness Natureland were alerted and they managed to persuade him back into the open sea. From Skegness he made his way across the Wash and into the River Ouse which enters the sea at Kings Lynn. He travelled unnoticed up river and finally came ashore at Salters Lode.

The Atlantic walrus

Left: Atlantic walrus in the Canadian Arctic.

Below: Wally at Salters Lode. It was feared that he might fall foul of fishermen trying to protect their nets so it was decided to try to take him to a place of safety. Eventually a net arrived in a helicopter–but getting him into the net was not so easy. He lay on the bank, watching the preparations with bloodshot eyes and then, when the final move was made to entangle him, he just rolled over and into the river and away into deep water. A couple of days later he was seen back around the Wash near Kings Lynn, where he was rescued by the Natureland staff. After the combined efforts of the World Wildlife Fund, the RSPCA, Icelandair and others he was flown to Iceland and transferred to an Icelandic coastguard boat which travelled west to the edge of the ice off the Greenland coast. Here Wally was released on to an icefloe and allowed to return to the wild. Like all good stories, this has a happy ending: Wally was almost immediately joined by a second walrus and when last seen they were just two small brown dots growing ever closer together and still swimming to land.

mature adults; females very rarely have such pouches. Air from the lungs can be forced into these pouches, which scientists think are mainly used as resonators when the walrus is vocalising. However, it has been suggested that they may also serve as a sort of 'lifejacket' when the animal is floating in the water.

British visitors Records of the walrus in the British Isles go back as far as 1456, when one William Caxton reported a walrus in the River Thames, while in 1527 Hector Boece wrote about walrus hunting in Orkney. It was not until the 19th century, however, that regular records appear. A Scottish naturalist, James Ritchie, reported in 1921 on a total of 23 sightings between 1815 and 1920, most of which were in Orkney and Shetland.

Some of these reports are rather sketchy and may even be of doubtful authenticity, but one sighting in Orkney, reported to the well known naturalist Harvie-Brown, was almost certainly genuine. This particular walrus was seen at close range by people who were annoyed by the animal as they went by boat to church on a neighbouring island. The walrus first made its presence felt by putting its tusks over the gunwhale of the boat–they must have been fortunate not to be capsized.

A walrus that appeared in Shetland in 1926 stayed around the islands for some time and became something of a local attraction. One observer described it as looking rather like a dirty bedsack that was almost submerged. The animal was first seen in late September and stayed around the islands for the best part of two months. After this report of 1926 there were no further records until a walrus made a brief appearance off the Aberdeenshire coast at Collieston in 1954.

Most of the animals seen in the British Isles have been juveniles, and of those where the sex has been determined the majority have been males. It is possible that young animals may become separated from their mothers and then drift with the prevailing currents that would carry them down from the Arctic waters they usually inhabit.

During the past few years there have been a number of walrus sightings in the North Sea, culminating with the visit of Wally in 1981. In addition there have been unconfirmed reports of an animal at Sumburgh in Shetland in 1976, and again in the Clyde in the summer of 1981.

BRISTOL BADGERS: AN URBAN SUCCESS

Unlike foxes, which are now common in many of our towns and cities, urban-dwelling badgers are relatively rare. They frequently forage in gardens on the edge of built-up areas, but only a few towns have well-established badger populations.

There are established badger populations in Edinburgh, Bristol, Bath, parts of London and the West Midlands conurbation, Basildon and Southend-on-Sea in Essex, and some of the south coast towns. Of these, Bristol far exceeds all the others in the number of badger setts per square kilometre; in some areas there are over 20 badgers per square kilometre–densities comparable with some of the best badger country in rural England.

Urban survivors Badgers are large, rather obtrusive animals, and at first sight it is difficult to understand how they have managed to survive in some of our built-up areas. For, unlike foxes, which are relatively recent colonists of many towns and cities, the badgers tend to be relict populations that have survived urban encroachment. The cities that do contain badgers are in areas where badgers are common in the surrounding rural areas, and where it would appear that the city developed in a locality in which the geology and general habitat were already eminently suitable.

In Bristol, for example, the badgers and their setts have managed to survive in three areas where there are river cliffs or sloping land and a diversity of geological deposits. In the two parts of the city where badgers are rare today they were probably always rare: the south is built on clay soils which are poorly drained and unsuitable for digging setts; similarly in the north, where clay soils predominate, badgers are rare.

Occasionally a badger may even live under the floorboards of an occupied house, entering through a broken air brick. In one instance a badger was living under the floorboards of a house undergoing renovation, where several floorboards had been removed to lay new piping. At night the badger would come up into the house to eat the cat's food, leaving dusty footprints all over the furniture and along the top of the piano. This caused some consternation, both to the old lady in the house and her cat, which was a somewhat nervous animal. The badger finally outstayed its welcome when one night the lady was awoken to absolute bedlam: the badger

Below: A badger tackles the scraps round a dustbin. In Bristol there are badger setts in steep-sided river cliffs, railway cuttings, rubbish tips, golf courses, allotments, factory sites and cemeteries. In the north-west setts are common in private gardens. Some of these are old setts that survived the inter-war period of house building; others have been dug recently under such places as summerhouses and garden sheds or in flowerbeds.

was chasing the cat round and round her bed!

Urban diet Besides stealing food from cats, urban badgers find a wide range of different food items from other sources. In rural areas earthworms constitute the major part of a badger's diet, but in towns these are of much lesser importance. In Bristol earthworms formed only 18% of the diet of badgers studied, whereas 20% consisted of insects and snails, fruit constituted 30%, scavenged food and food put out by householders 24%, vegetables–mainly garden crops–5%, and vertebrates–predominantly garden birds –nearly 3%. Fruit is clearly the most important food item for the Bristol badgers, and in autumn when windfall apples, plums and pears are available in abundance, nearly two-thirds of the diet is fruit. The range of foods taken is amazing, including blackberries, mulberries, gooseberries, strawberries, medlars, raspberries, and red and black currants.

While no-one would begrudge the badgers their windfall fruit, unfortunately they are very partial to strawberries, gooseberries and raspberries and cause considerable damage both to soft fruit crops and fruit cages. Badgers are also very keen on new potatoes and carrots, and where badgers are common most people just give up trying to grow carrots. The moment the crop is ready the badgers take it all–overnight an immaculate vegetable garden is devastated as the badgers root out every carrot. In the hot dry summers of 1975 and 1976 damage to garden crops was particularly severe.

Badgers can certainly make their presence felt in towns. In one area of Bristol where they are common 16% of householders had their dustbins regularly rifled by badgers–they were even more persistent than foxes which can easily jump garden fences. Instead, the badgers simply knock a hole in the fence; 10% of the householders questioned reported badgers breaking fences. Not surprisingly, therefore, to some people the badger is an unwelcome addition to our urban fauna.

Above: In Bristol it is quite a common occurrence for people to be woken in the middle of the night by the sound of a badger tearing a big hole in the garden fence. Badgers are creatures of habit and follow regular tracks between gardens. Any attempts to block these runs are vigorously resisted by the badgers, and many people resign themselves to having one or more permanent holes in the garden fence.

Urban behaviour The behaviour of badgers living in urban areas is different from that of those in rural areas. The badgers emerge from their setts about an hour later than animals in the country, and are rarely out before it is completely dark. Where the roads are busy, activity may be further restricted until the traffic dies down, after which the animals readily move about on the roads–the sound of their long claws clattering on the tarmac as they run along is clearly audible from some distance. In the morning town badgers do not return to their setts any earlier than those in rural areas, and in mid-summer can sometimes be seen trotting home in broad daylight.

The badgers are not active throughout the whole night; periods of activity are interspersed with periods of sleep when the badgers may either return to their setts or crawl under a shed to sleep. Sometimes a fox and a badger sleep under the same shed. Badgers will even build a couch of dry grass or leaves under a garden bush on which to rest during the night. One has even been seen asleep in the middle of a school field. In July badgers spend the greatest proportion (65%) of the night active, this dropping to as little as 8% in January when they are rarely active above ground and move only small distances from the sett. They do not hibernate, and are often active underground, but they do live off their fat accumulated in autumn when windfall fruit is available in abundance.

Badgers have adapted many aspects of their behaviour to life in our cities. In lowland areas of rural Britain they live in well-defined social groups, each of which defends a territory, and the boundaries of these territories are marked with large latrines. In towns the territorial system is far less rigidly defined. Instead of clear-cut territorial boundaries with conspicuous boundary latrines, the fringes of each group's foraging area are poorly defined and may overlap with those of adjacent social groups. In rural areas most badger latrines are

Below: A badger visiting a garden to take table scraps left out for its benefit. Many people put out food for badgers, but they also take garden produce, fruit, insects and snails.

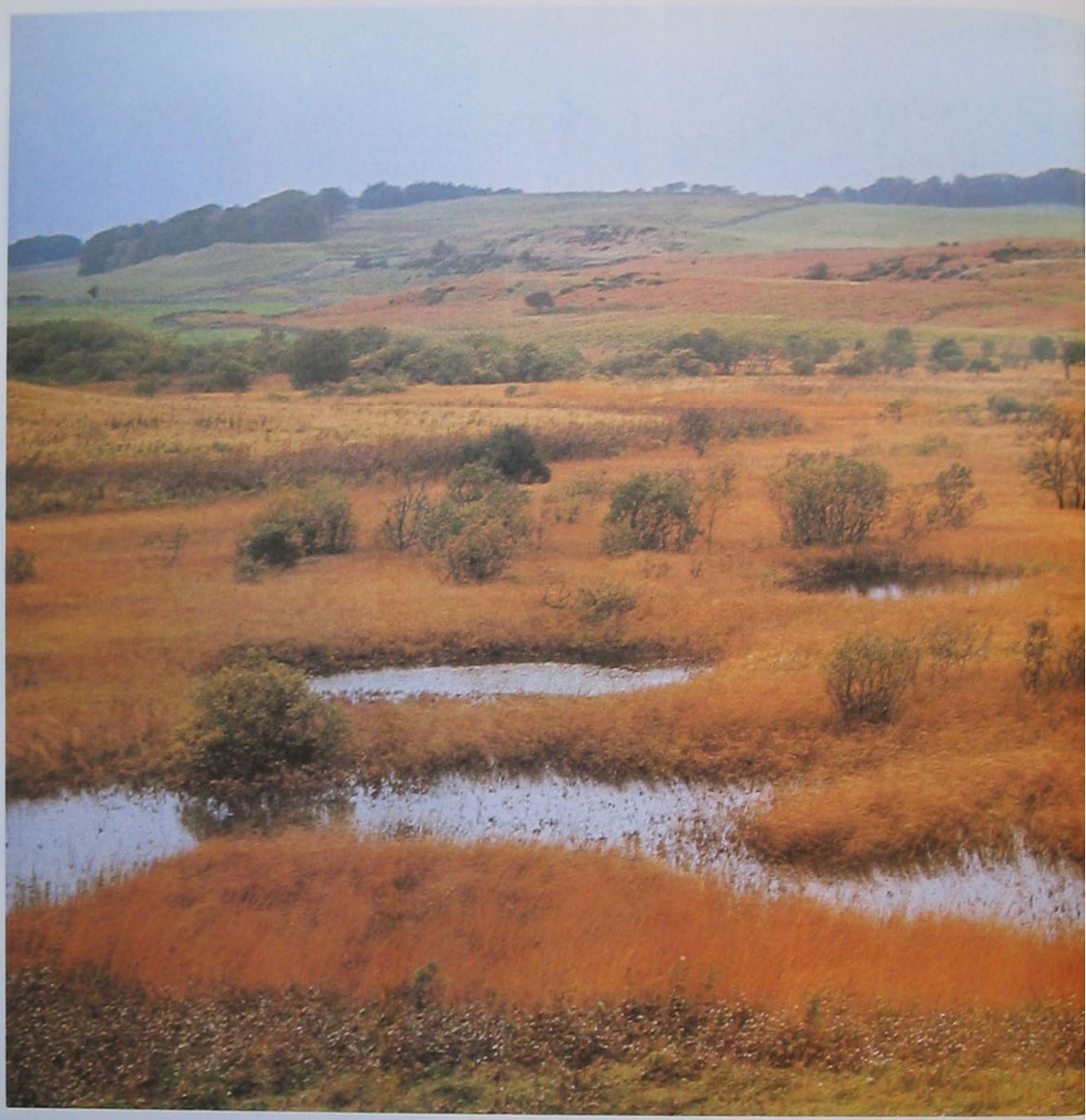
found on the boundaries of the group's territory, with relatively few sited near the setts. In towns the pattern is exactly the reverse: the area around the sett is heavily marked with latrines, with half the latrines less than 50m (165ft) from the sett, and there are relatively few latrines towards the periphery of the foraging area.

This change in behaviour is a response to the diverse nature of the urban habitat and the wide range of food sources available. In rural areas the badgers specialise in feeding on one main type of food–earthworms. Their territory is designed to encompass several potential sources of earthworms, and these feeding areas are predictable and worth defending. In towns the food sources are more varied but less predictable, so the badgers in towns forage in a more random manner than in rural areas, checking many potential food sources and often travelling long distances criss-crossing a small area. Hence, although it may be foraging in an area of less than half a square kilometre, the badger may travel over 8km (5 miles) on a summer night, thoroughly searching this small area.

In most towns the habitat is diverse and in Bristol badger home ranges vary according to the type of area where they live. So animals whose range consists mainly of gardens have large home ranges and the badgers eat a diversity of food types; in smaller home ranges the habitat is more varied and the animals take a smaller variety of food types–the situation is similar to a rural area where the badgers specialise in obtaining one particular food.

Although town badgers modify their behaviour to suit their environment, they are not permanently adapted to urban life. In Bristol some badgers born in the town move out into the surrounding countryside, and animals from the countryside probably still move into the town. Clearly the urban and rural badger populations are not living as distinct populations. There are a number of problems for urban badgers. The major cause of death is road accidents. Some die in swimming pools; cubs particularly are killed by large pet dogs; and some get entangled in garden netting. Quite a few are also trapped by humans.

Above: Bedding which has been dropped by a badger and (above left) distinct signs of a badger in the soft turf of a garden lawn. Urban badgers (like the one below) are safest in gardens and will only survive in our cities with the help and tolerance of the people living in them.

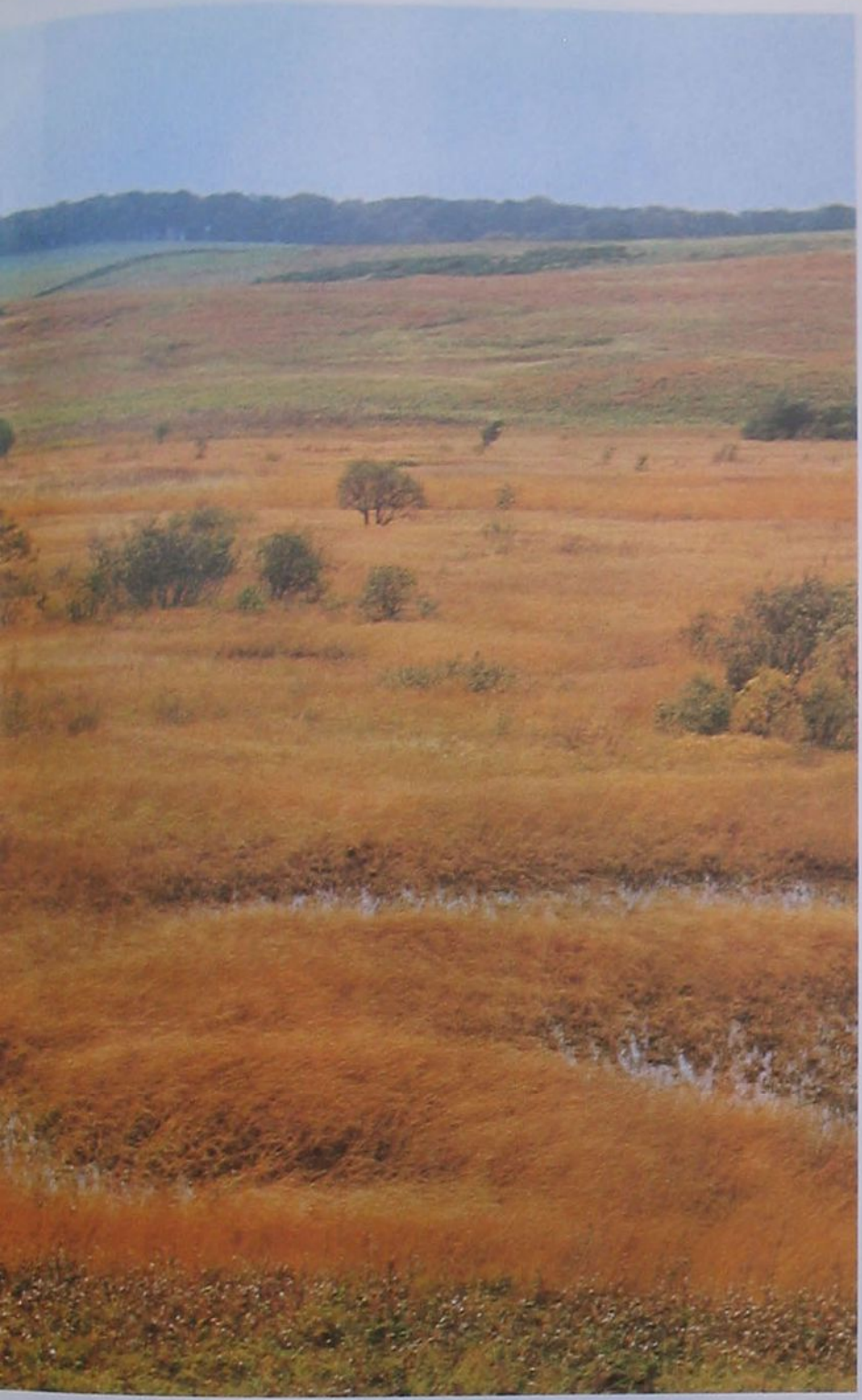


WHITLAW MOSSES NATURE RESERVE

The Borders Region of south-east Scotland contains one of the highest concentrations of mires in the country. Lying amid the smooth, rounded hills of the central Borders are four mires of national importance, together known as Whitlaw Mosses.

Whitlaw Mosses National Nature Reserve consists of four separate mosses (the word moss being a regional name for a small confined mire). The four are Murder Moss, Blackpool Moss, Beanrig Moss and Nether Whitlaw Moss. They all lie within a mile of each other, and together their total area is no greater than 20ha (50 acres).

The high density of mires in the Borders region of Scotland is due to the geology of the area, helped by the activities of ice sheets during the Ice Ages. Huge forces on the rocks caused the landscape to buckle and fold, in places creating rock strata that were close to being vertical. Then, during the Ice Ages, a succession of ice sheets covered the area,



eroding the softer exposed rock strata more than they did the harder layers, thus creating a series of ridges and hollows.

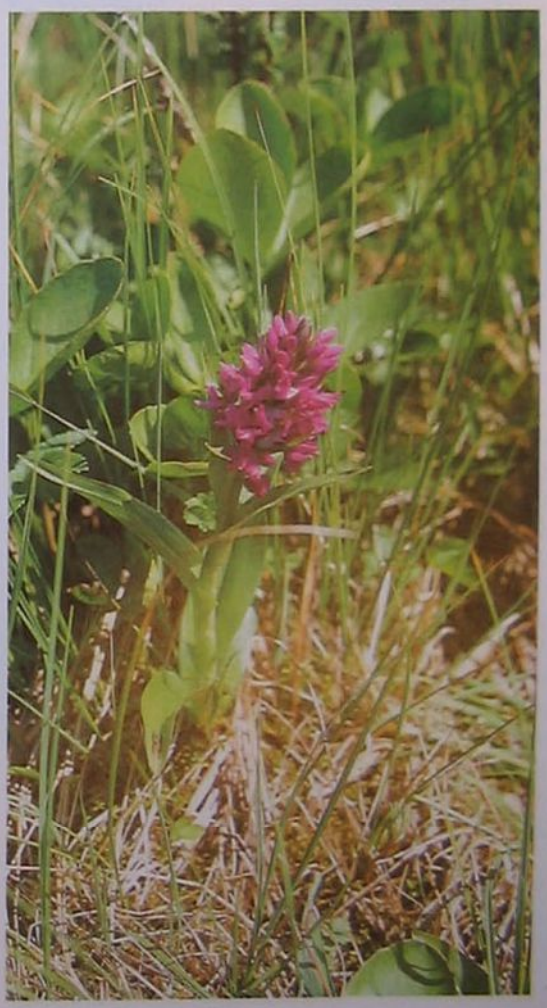
All the Whitlaw Mosses lie in hollows carved out by the ice sheets. With the passing of the last Ice Age, the sea rose to its present level and the hollows were flooded to become lochs. Then, as they silted up and vegetation moved in, they gradually developed into mires.

Types of mire A mire is formed when a gently sloping valley or a hollow becomes waterlogged. The result is that the oxygen level in the water drops and so plant remains decompose only very slowly, the material building up as peat. (Mire, by the way, is a wider term than bog. Most, if not all, peatlands are mires, but if they are to be called bogs as well, then they have to satisfy other conditions.)

Two important types of mire are valley mire and basin mire. In valley mires there is a slight movement of water down the valley slope, usually via a central channel, whereas true basin mires have a level, generally stagnant, water table. This is the condition at its simplest. Quite often, so-called basin mires have drainage channels at the surface, and an inflow and an outflow stream. Such a mire can only be described as a 'basin-valley' mire, of which the Whitlaw Mosses are good examples.

Rich fen and poor fen The kinds of vegetation found in basin and valley mires are determined partly by the height of the water table and partly by the nutrients in the water. Water flowing over rocks such as limestone, which is rich in minerals, gives rise to a much more diverse range of plants in the mire than does water flowing over rocks poor in minerals. The former mire–rich in minerals and usually alkaline–is called rich fen while the latter is known as poor fen, or more commonly a bog. A poor fen is lacking in minerals and is usually acidic.

In the case of Whitlaw mosses, the land consists of bands of limestone shale among more acidic rocks. These bands enrich the waters entering the mires with lime, which has



Above: Murder Moss, one of the four Whitlaw Mosses. The apparently uniform, even uninteresting, look of this mire, which is typical of Border Region mires, is deceptive. A close inspection would reveal a great diversity of rich-fen species and a profusion of invertebrate life.

Right: As its name suggests, the northern marsh orchid is a distinctly northern species common in fairly nutrient-rich fens and damp meadows.

Above: Found only in the north of England and throughout Scotland, the Scotch argus is a common butterfly on Border Region mires such as Whitlaw. In late summer they become the most numerous butterflies in a habitat not noted for such insects.

Right: The rare coral-root orchid grows in the dense shade of the willow carr on two of the Whitlaw Mosses. Growing to a height of 25cm (10in), pale yellow-green flowers are borne from May to July (above right). This plant relies for growth more on the association between its coral-like rhizome (below right) and a fungus than it does on photosynthesis–hence its pale green stem.

encouraged the development of rich fen. In many mires a clear gradation can be seen from rich-fen plants in one part to poor-fen plants in another. In valley mires with a central channel rich in nutrients, the rich fen tends to form along this, decreasing as you move away from the channel to become poor fen at the outer margins. A basin mire, however, if fed by enriched waters at the mire's edge, has rich fen at the edge and poor fen in the middle. In Whitlaw Mosses, only Beanrig Moss shows any clear zonation of the plant communities, though all four mosses have poor fen as well as rich.

The plant communities The most obvious feature of the Mosses' vegetation is the willow carr. This is best seen in the large carr of Blackpool Moss, dominated by common sallow with tea-leaved willow, goat willow and the bay willow, with its glossy leaves. On all the Mosses the carr is surrounded by extensive areas of sedge swamp and moss fen. Beneath the willows the ground flora consists of fairly uniform stands of horsetail and meadowsweet, with a carpet of mosses including the spear-tipped *Acrocladium cuspidatum*, leafy species of *Mnium*, and *Climacium dendroides* looking rather like a miniature tree about an inch or so high.

A careful search through the undergrowth of the carr may reveal the rare and inconspicuous coral-root orchid. Another northern species, the northern marsh orchid, occurs outside the carr in the rich sedge swamps. The robust purple flower heads of this orchid are easily seen among the sedges, of which the bottle and slender sedges are the most common. Horsetails are also to be seen here, and there are pockets of greater spearwort with its yellow flowers–a close relative of the buttercups. In places the sedges share their dominance of the swamps with the marsh cinquefoil–a striking plant with purple flower heads–and the tough-rooted but highly attractive bogbean. The pink-flowered marsh lousewort and the marsh hawk's-beard also grow in the sedge swamp.

In slightly drier swamps, still in areas of rich fen, the vegetation changes to plants such as round-leaved wintergreen, water avens, angelica and grass of Parnassus.

From Moss to Moss The vegetation varies somewhat from one Moss to another. On Blackpool and Murder Mosses common reed grows in dense stands about 2.5m (8ft) tall, usually on sites that were once open pools. In the centre of Murder Moss are rectangular pools, the remnants of former peat cuttings long disused. Here can be found marestail, common and small bur-reed, floating broad-

Below: An insectivorous plant, round-leaved sundew grows in the acid, poor fen conditions found in parts of Beanrig Moss.

leaved pondweed and the insectivorous plant, bladderwort. Next to the pools are carpets of brown mosses and flea and glaucous sedges, all species that thrive in the lime-rich conditions found there.

Beanrig Moss has some good examples of poor or acid fen. These are interspersed between areas of rich fen and contain hummocks of a wine-red species of *Sphagnum* moss, with cranberry, sundew and cross-leaved heath–all plants requiring an acidic environment. Beanrig Moss, therefore, has hummocks of acidic poor fen surrounded by hollows of rich fen where the water is neutral.

Nether Whitlaw Moss is the most uniform mire of the four, with extensive *Sphagnum* lawns in the poor fen, and some localised pockets of rich fen. This Moss is a good example of a floating mire, where plants such as bogbean have grown over the surface of the water. The result can be very dangerous to the unsuspecting walker.

Above: The most common and evident dragonfly on the Reserve is the black darter, so-called because of its restlessness, alighting on plants after just short bursts of flight. Only the male, shown here, is truly black. The female is mainly yellow and brown.

Below: A secretive bird, but highly amusing to watch and extremely noisy, is the water rail, which breeds on all four of the Whitlaw Mosses. Often heard grunting, squealing and whistling among the reeds, it occasionally approaches quite closely before scurrying away, its red beak adding a splash of colour to the undergrowth.

Whitlaw Mosses National Nature Reserve is private land managed and protected by the Nature Conservancy Council in agreement with and with the co-operation of the land's several owners and tenants. The Mosses are dangerous and easily damaged. To protect them and the public, permission has to be obtained from both the owners and the NCC before visiting.

Whitlaw's animals The Mosses provide an ideal breeding ground for a small range of fenland birds. In early summer the reeds and sedges come alive with the raucous chatter of sedge warblers, offset by the sweeter notes of the willow warbler in the trees. Reed bunting, redpoll and several more common woodland birds breed on the Mosses, or are frequent visitors to them. Occasionally the reeling song of the grasshopper warbler can be heard as this shy bird flits back and forth between tall reeds and low cover. Another shy bird, the water rail, is present on all four of Whitlaw's Mosses, while the more evident snipe is always present in the swamps in large numbers. Herons wait motionless by the sides of pools for unwary frogs, sticklebacks and small pike to pass by.

Invertebrates abound in the fens, the less conspicuous among them being the most interesting. In recent years three species previously unrecorded in Britain–a true fly, a sawfly and a water beetle–were first found at Whitlaw. Several other rare species occur here, including a flightless water beetle, which indicates that the habitat is relatively undisturbed.

The fens are not well known for their butterflies, but there is a large colony of Scotch argus due to the presence of their larval foodplants, purple moor grass and meadow grass. This species is the last butterfly on the Mosses to emerge, having only one brood in the later summer. A sun-loving species, it often vanishes suddenly during cloudy spells, only to reappear when the sun comes out.

The open water pools attract several species of damselfly and dragonfly. The most common of these is the black darter; more colourful are the common blue, large red and emerald damselflies.

RIVERS AND LAKES: FISH HABITATS

Freshwater fish species have very distinct preferences for particular habitats, thus partitioning the living space and minimising competition.

If one stands at the mouth of a large river where it joins the sea, the mass of turbid, brackish water looks totally different from the tiny tumbling brook at its origin in the distant hills. The physical conditions are different, too: the estuary water is brackish, relatively warm and well oxygenated at its surface, though less so on the river bed. The bed is mostly muddy, and the currents are moderate.

The headwater stream, in contrast, contains clean, more or less pure fresh water which is cold and well oxygenated throughout. The bed is rocky and the flow fast–and always downstream, in contrast to the estuary, where tides wash the water to and fro. In between these extremes almost all the physical features change, and it is not surprising that there are no fish which can be said to belong to both. A few species, however, spend some of their lives in both environments.

Brackish water At the estuary the fish fauna is affected by the presence of salt water from the sea. The fishes are those which, by their physiology, are capable of living in brackish water. Some of them are sea fishes, such as sprat, herring, whiting, sole and dab. Most of these are young fishes, for the wide, shallow estuary is an important nursery for such species, with its sheltered waters and abundance of small food organisms.

More typical of the mouth of the river are such fishes as the flounder and the smelt (*Osmerus eperlanus*). The flounder breeds in the sea, but the young fish quickly find their way into river mouths. While no larger than the size of a postage stamp, they migrate up the river. Too small to swim against the downstream flow, they ingeniously use the tidal currents, swimming in mid-water or at the surface while the tide is running upstream, and then seeking shelter on the bottom when the tide ebbs and the flow is downstream.

The smelt, on the other hand, migrates upstream early in the year to spawn in spring, shedding its eggs over the exposed gravel bed of the river.

The estuary is the temporary habitat of the salmon and the sea trout, while on passage as young smolts downstream to the sea, or as

Above: Cadman's Pool in the New Forest, Hampshire, is a lowland lake with a good supply of nutrients for algae and larger aquatic vegetation such as reeds. Although the water is still, the lake is a habitat for a range of fishes broadly similar to that of the lower freshwater reaches of a river: fishes of the carp family (cyprinids) predominate. Bream, roach, tench, crucian carp and rudd all occur. The submerged vegetation offers sanctuary to smaller fishes, especially the three-spined stickleback, and to the young of the cyprinids. It also offers hiding places for the pike, both for the baby feeding mostly on insect larvae and for the well-grown jack lurking under cover before charging at a passing roach or perch. The quiet water beside landing stages or bridges also provides hiding places for large, fish-eating trout, and for big perch.

adults making their way upstream to spawn–mostly in the early winter. The freshwater eel is also an inhabitant of the estuary. Many eels actually live there, although most pass through in January to April as elvers, having migrated from the sea, while large eels come downstream later in the year en route for their spawning grounds in mid-Atlantic.

Lowest freshwater reaches Further upstream, the river's character changes. The sea's influence is no longer felt and the water flows downstream all the time. The slope of the river bed is very gentle, indeed it is usually flat, and the current is slow (except when the river is in spate after heavy rain). The water is comparatively warm, sometimes in summer as high as 20°C (68°F), and oxygen levels are moderate at the surface and in mid-water, though low on the bottom. The water is cloudy with detritus. This region of the river is typical of the lowland area, with tree-lined banks and the rich grazing land of the floodplain meadows. Most of the landscape is of fields interspersed with copses and bounded by hedgerows, but many towns and human habitations also exist in these regions.

In a typical river of this kind in England, the fishes mostly belong to the carp family: bream and roach are particularly common. Bream tend to keep near the river bed, for their protrusible mouths are well adapted to feeding on the bottom, sucking worms, insect larvae and even molluscs out of the bottom mud. Roach, being very adaptable, also feed near the bottom and in mid-water, as well as near bankside vegetation, which may be dense in places.

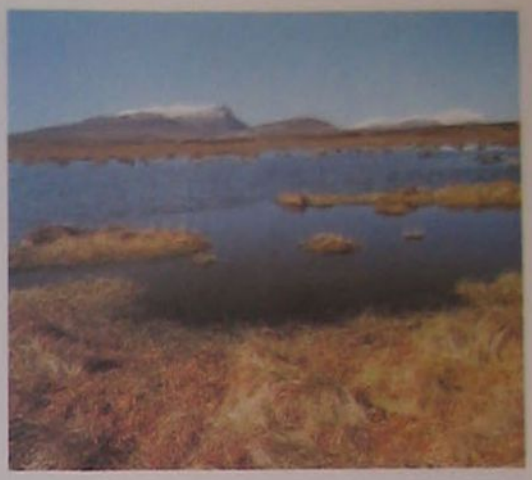
Near the surface of the river the bleak is common, feeding as much on insects which fall into the river from overhanging trees or from the air, as on crustaceans in the water. In backwaters where the flow is even slower and water plants grow densely, tench, carp and rudd live in conditions where temperatures may be higher and oxygen levels lower than in the main river.

Man-made waters Lowland rivers of this kind have always been important for navigation, and particularly during the 18th and 19th centuries most of the larger rivers of England, and some Scottish rivers, were joined together by canals to allow barge traffic. This greatly increased the area of living space for fishes. So, too, did the construction of reservoirs to store drinking water in lowland areas, the extraction of gravel in river flood plains leaving gravel pits, and the building of ornamental lakes.

All over the lowlands, more habitats became available, and most of these were particularly suited to the fishes of lowland rivers. Carp, which were introduced in medieval times for monastic fish ponds, are particularly successful in the warm, still waters created by man, as are tench, crucian carp, roach, bream, perch and pike. As a

Mountain tarn

A shallow tarn in the mountains of northern Scotland (right). Ben Loyal and Ben Hope are on the skyline. Like the peaty soils of the surrounding countryside, the water that drains into this tarn is acidic and poor in nutrients. The fish fauna is similar to that of the uppermost headwaters of a river: probably only trout and salmon. The habitat is relatively safe from predatory birds and fish (other than the trout).



Upper reaches

The rushing stream at Langstroth in Cumbria (right) is a typical example of the upper reaches of a river: it is narrow and has a steep bed, giving a rapid current. Minnow, bullhead, trout and grayling occur in upland rivers at this altitude, each species requiring its own type of habitat. In such tumbling waters as these, the fish take refuge from the fierce current in the lee of rocks or under stones.

Lowland reaches

The river Ivel (right) near Sandy in Bedfordshire has a relatively fast flow for a lowland river. It drains rich agricultural land and is well supplied with nutrients: the resulting prolific growth of aquatic weeds, and plentiful vegetation on the banks, create good conditions for fishes of the carp family: chub, bream and roach, with bleak near the surface. In slow backwaters, carp and rudd are found.

Brackish waters

An estuary in the south of Ireland, seen at low tide (right). The bed is composed of mud and the current is moderate. Young flounders are typical of this kind of environment, as are adult smelt. Salmon, sea trout and freshwater eels occur here at various stages of their life-cycles. There are also visiting thin-lipped grey mullet, and the young of many sea fish species: sprats, herring, whiting, sole and dab.

result, the total area of water available to these fishes has been greatly increased and their distributional range has also grown.

The perch is often common in such habitats, usually keeping close to submerged plants, but sometimes can be seen in large scattered schools searching for food along the concrete aprons of reservoirs. As a fish-eating predator, at least when fully grown, it is never so common as the prey species, such as roach.

The closest native relative of the perch, the ruffe, is a bottom-feeder and lives in rather clouded water, but as it has a series of open sensory pores along the underside of its head, it scarcely needs good vision to find the larvae of the chironomid midges on which it feeds. These live buried in the mud and must be detected by non-visual means. The ruffe has found that canals and man-made lakes are particularly good places to live.

Middle reaches Further upstream in a typical river, physical conditions change. The slope of the river bed increases and as a result the river flow is faster. The water is turbid after rain, but runs clear in dry weather; it is moderately warm, often up to 60° F (15° C) in summer, and oxygen levels are high, but a little lower near the bottom. The river bed is gravelly, with sandy mud at bends and mud in the backwaters, and submerged vegetation is fairly rich but grows mainly outside the areas of strong flow.

This region is again dominated by carp family fishes, the most common being dace, chub and barbel, while the roach is still common, and in the deeper pools gudgeon live on the river bed. Perch and pike are still common in this kind of river, but usually avoid the strong current by lying close to weed beds and in the deeper meanders. In shallow water under stones the stone loach is common, as are occasional minnows, which also live in weeds in shallow water where sticklebacks abound.

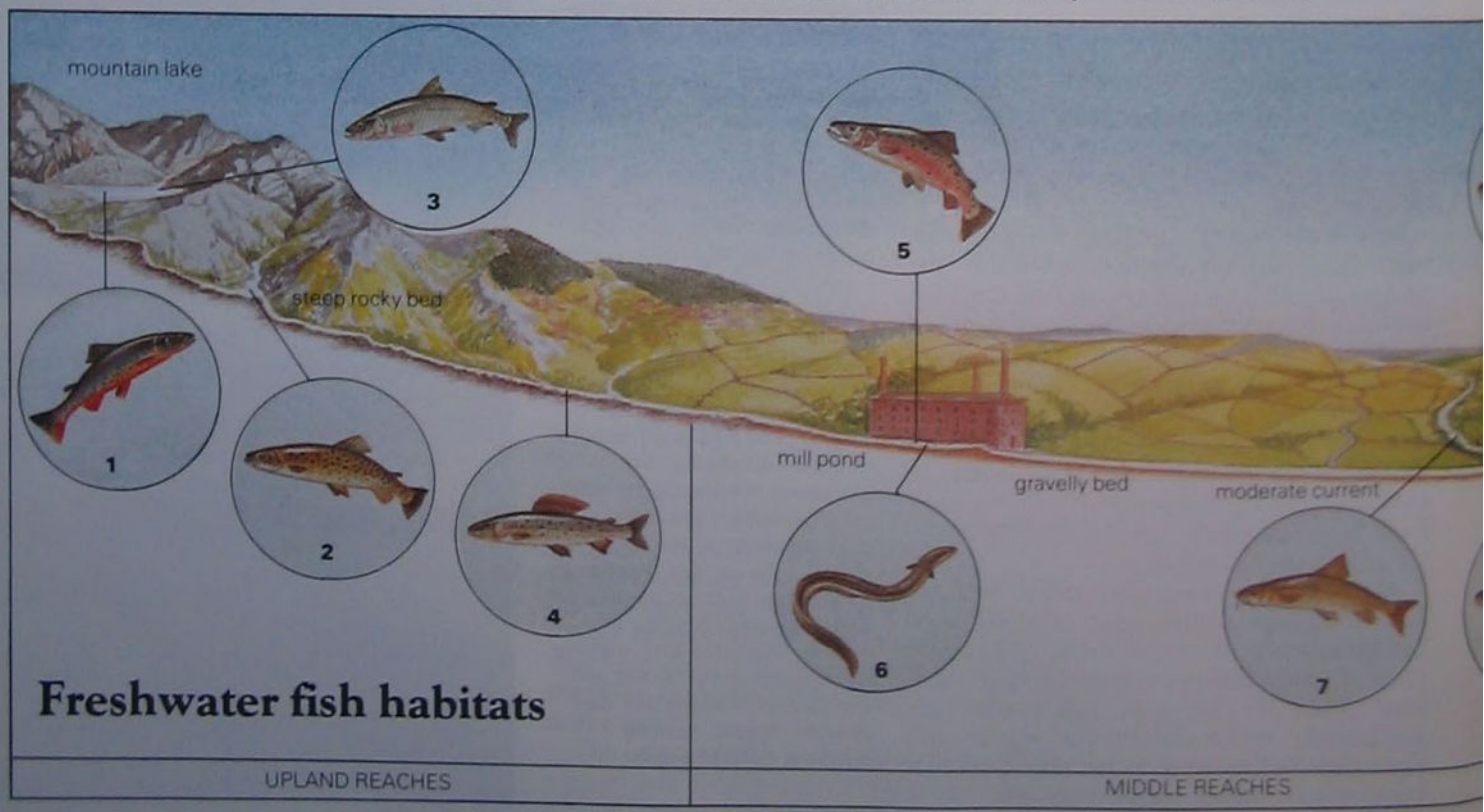
Millpools and weirpools In many places, rivers like this are maintained at a fairly

Above left: A fully grown flounder. Young flounders migrate up the rivers to freshwater reaches, then return to the sea to breed.

Above: The perch feeds mostly by sighting its prey from afar and then stealthily moving close; it lives for preference in clear water near the surface.

Above right: A jack or young pike. These hunt among the submerged vegetation, while larger pike may simply find quiet water near the mainstream of the river and lie in the shadow of a tree or moored boat. Here they wait for prey.

Far right: Barbel spawning in a gravelly stream. The darker fish is the female.

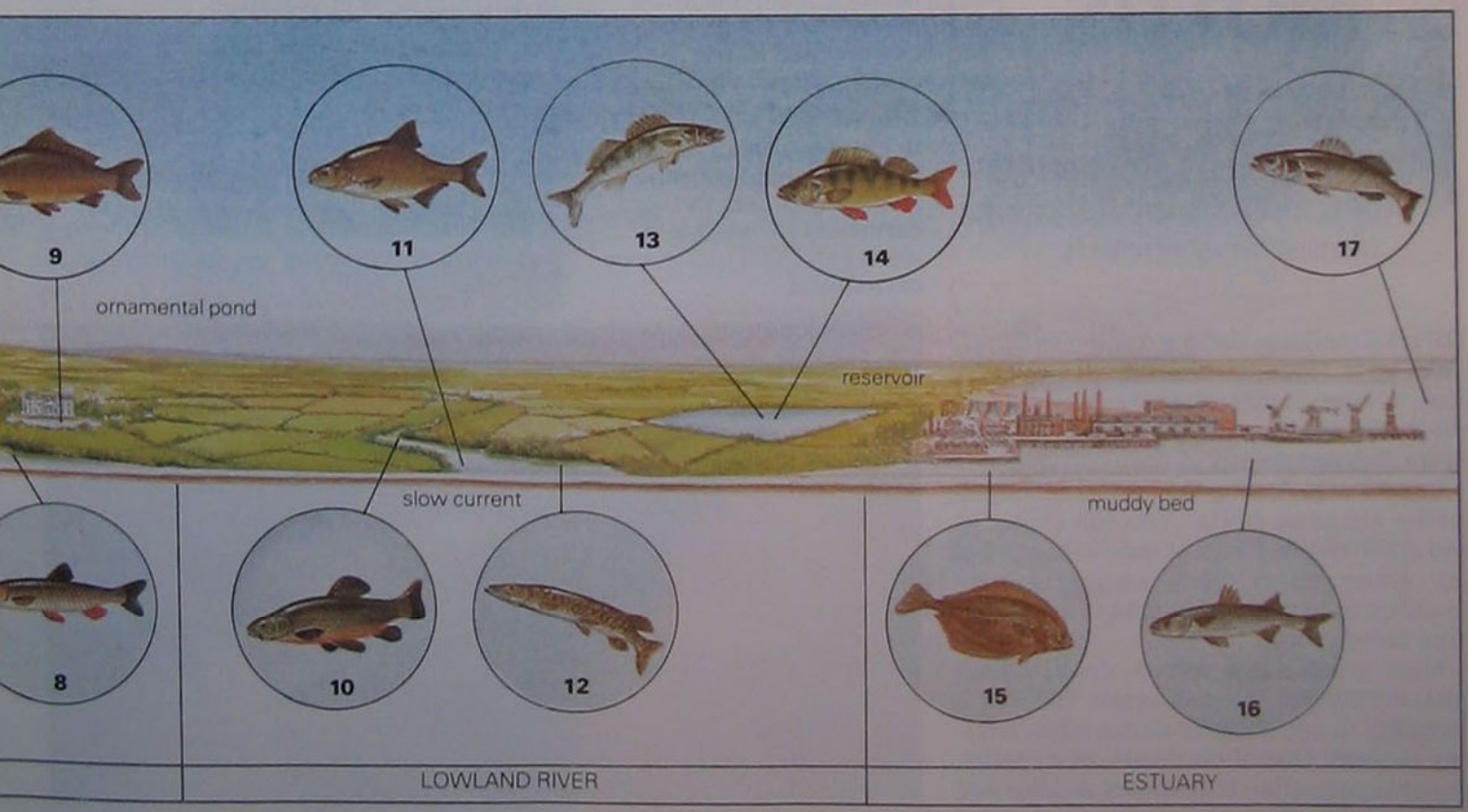


constant depth and rate of flow by the building of weirs. The resulting weirpools have become a special habitat in which large chub, trout, roach and pike live. The weirpools are plentifully oxygenated by the turbulence of the falling water. A similar habitat for these fishes is the millpool, where the river has been dammed, producing a pool with less turbulence but plenty of deep water. These pools are classic sites for migrating salmon to gather their way upstream, sometimes perhaps just resting in the deeper quiet waters, at others waiting for rain to increase the flow of the river so that the journey can recommence.

Upper reaches Further upstream the river becomes narrower, the slope of the bed steeper and, as a result, the flow faster, with clear cool water which is well oxygenated. This is the region where the grayling, minnow, dace and trout are most common, all of which find such conditions to their liking. Here, too, many salmon spawn, cutting their nests in the gravel beds of the fast flowing river in January. Only the most athletic of large fishes can cope with the current, and most of the small species, and young fish of all kinds, hide among rocks or shelter in the backwaters or tributaries, while bullheads hide under stones.

Mountain lakes The physical conditions of the upper reaches of rivers, with their low temperatures and high oxygen levels, are similar to the conditions in many mountain lakes–particularly those known as 'acid' lakes, which are characterised by a relative scarcity of plant and animal life. Not surprisingly, native fishes in the lakes tend to be the same as those of the upper rivers: trout are the most widespread, but minnows and bullheads are also common. These lakes also contain Britain's charr and whitefish populations, which favour such conditions. However, man has busily introduced fish to such areas and many upland lakes now contain pike, perch, roach, rudd and other species that are not native to them.

1 Charr: mountain lakes
2 Trout: mountain streams; rivers; lakes.
3 Whitefish: as charr.
4 Grayling: upland reaches.
5 Salmon: all reaches.
6 Freshwater eel: all reaches; lowland lakes.
7 Barbel: middle and upland reaches.
8 Chub: middle reaches.
9 Carp: lakes, man-made waters, lowland rivers.
10 Tench: man-made waters, backwaters.
11 Bream: lowland waters.
12 Pike: lowland and middle reaches; lakes.
13 Zander: lowland rivers and lakes; man-made waters.
14 Perch: lowland and middle reaches; lakes; canals.
15 Flounder: estuaries.
16 Grey mullet: as bass.
17 Bass: sea, estuaries.



OUTDOOR PYRALID MOTHS

If you walk through long grass in summer you may put up large numbers of grass moths, but they soon disappear again, almost mysteriously.

Above: The mother-of-pearl (*Pleuroptya ruralis*) derives its name from its attractive wing colouring. If you wish to see this species, shine a torch near a patch of stinging nettles at night–the moths are attracted by lights and one may well fly out.

Below: The garden pebble (*Evergestis forficalis*) may look harmless, but its caterpillars are capable of ruining an entire garden crop of cabbages.

The grass moths, as they are commonly called, make up a separate subfamily of the Pyralidae, a large family of moths consisting of about 200 species which occur almost anywhere, but particularly in open country.

Grass moths Among the pyralids about 35 species are grass moths. You can expect to find at least half a dozen of these in just about any grassy patch. They are particularly abundant in hay fields, but tend to keep away from cereal crops.

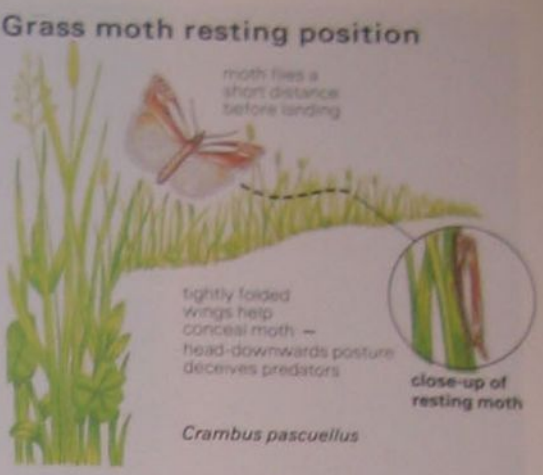
Most grass moth species do not have generally accepted English names, and so it is necessary to use scientific names when referring to them. One of the commonest species, *Crambus pascuellus*, is abundant in fields and meadows, where it flies at night, although you may easily disturb it by day as you walk through long grass. It has rather long, narrow, pointed forewings which are pale brownish and beautifully patterned with silvery-white. Its broad whitish hindwings are folded and completely hidden by the forewings when the moth is at rest, giving the impression that the moth is smaller at rest than when in flight.

Disappearing act When a flying moth lands on a piece of grass it flips over and settles in a head-downwards position, deceiving predators such as birds and lizards. Such predators usually strike first at the head of their potential victim, but in this instance a blow at what should have been the head is a blow at the rear end of the moth. Since the moth's folded wings extend well beyond the length of its body, the predator usually only damages the wing-tip slightly, enabling the moth to escape by flying away. This neat and striking behaviour occurs in a number of small moth species.

The grass moths' caterpillars inhabit silk-lined galleries constructed in grasses and reeds, some species actually living underwater. They mainly feed internally on the grass pith at the base of the plant. The caterpillars themselves are rarely seen, unless you split grass and reed stems open and examine them closely. However, their presence can sometimes be detected by particles of their droppings entangled in lengths of silken thread near the base of the grass stems.

Other pyralids Although grass moths are more likely to be seen than most other members of the Pyralidae, there are a number of other pyralids which are often encountered and easy to distinguish. One of these is the gold fringe, a most attractive moth with yellow-bordered purple wings. It is fairly common in the countryside and is sometimes seen in gardens in southern and central England. The caterpillars feed on hay in haystacks and, occasionally, on the straw of thatched roofs.

The rush veneer is a brown moth with a semblance of 'veneering' on the forewings. It is an unusual pyralid as it is largely a migrant



from the Continent, arriving here every year in early summer. There are records of the moth being attracted to the lights of ships in the English Channel, but there is no doubt that, although rather small and delicate looking, the rush veneer is perfectly capable of flying considerable distances across the open sea. The caterpillars feed on clover and lucerne.

Nettle bed inhabitants If you cut down or disturb a clump of stinging nettles in July you cannot fail to notice large numbers of two pyralid moth species–the mother-of-pearl and the small magpie. On being dislodged from their daytime resting places these moths fly short distances and then settle again, usually on the underside of a nettle leaf.

In spring, soon after the nettle shoots have started to sprout from the ground, the presence of mother-of-pearl caterpillars can be detected by finding leaves spun together with silk threads. Pull the leaves apart and a wriggly green caterpillar is revealed; later in June you will find a black pupa among the leaves.

The small magpie occurs throughout Britain (like the mother-of-pearl), but is rather local in Scotland. The caterpillars live in leaves which they spin together, and are most often found before hibernation in August and September.

Cabbage destroyer Another pyralid which is fairly easy to distinguish is the garden pebble moth, identified by the pebble-like pattern on its forewings. Common in gardens, it flies at night in May and June, and in August and September when there is a second generation. The green caterpillars feed on cabbage leaves, often attacking the heart, and are capable of causing more damage than the notorious white butterfly caterpillars. The garden pebble caterpillars also occasionally feed on a variety of related plants, such as turnip and horse radish.

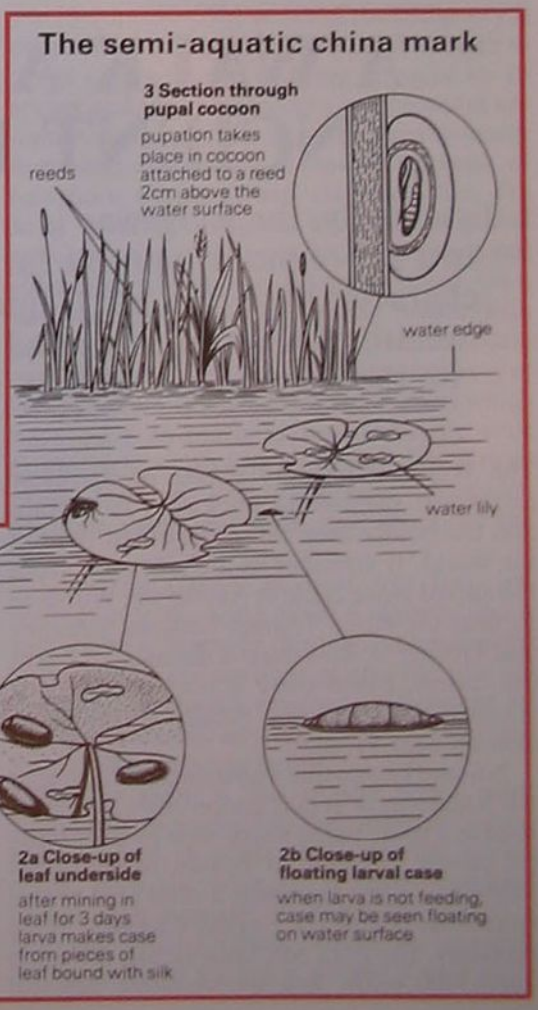
When fully fed the second generation caterpillars burrow into the soil and construct an earthen cocoon in which they spend the winter, pupating without feeding in the spring. This is unusual among moths, as most species that overwinter in cocoons do so as pupae.

Above: The small magpie moth (*Eurrhypara hortulata*) is recognised by the black and white markings on its wings. If you allow a patch of nettles to grow in your garden you may well attract a breeding colony of small magpie moths. Their caterpillars spin together the leaves of the nettles among which they live.

Right: The brown china mark (*Nymphula nymphaeta*) is an unusual pyralid moth as part of its life-cycle takes place in the water.

Gold fringe moth
(Hypsopygia costalis)

Rush veneer moth
(Nomophila noctuella)



A WALK ALONG THE ANCIENT RIDGEWAY

Essentially, the Ridgeway is a long peninsula of chalk upland in a sea of modern arable farmland. Much of its chalkland character has gone, but fragments here and there support a wealth of plants, insects and birds–seen to best advantage on the route of our walk in the months of June and July.

The Wessex Ridgeway is one of the most celebrated prehistoric trackways in Britain and has boldly been called the oldest road in the world. It stretches as a chalk ridge from the sacred stone circle at Avebury in Wiltshire to near the River Thames between Streatley and Goring in Berkshire–a distance of 64km (40 miles). From there it continues by the Icknield Way, ending finally at Ivinghoe Beacon near Tring.

No-one knows quite how ancient the use of the Ridgeway is. It may conceivably have been used as a route to the south-west by Continental people crossing to Britain some 10,000 years ago, when there was a solid land bridge over what is now the English Channel. More certainly, the path has been in use for some 4000-5000 years, first by Neolithic pastoral people, then by Bronze Age dwellers who are credited with the foundation of Avebury and Stonehenge, and later still by waves of invaders–the Iron Age Celts, then the Romans and Anglo-Saxons.

The Ridgeway served the needs of these changing cultures in a multitude of ways–for agriculture, passage of trade, defence and, not least, for sacred rites. The Bronze Age burial chambers, called 'barrows' and 'tumuli', testify to the Ridgeway's use as a funeral route, while the great earthwork forts, such as Uffington, demonstrate the growing pressures on the Celtic settlers to defend their territorial advantage and, indeed, safe access to the west, for it is clear that the Ridgeway was part of a wider network leading beyond to Salisbury Plain and the Dorset coast.

Above: A view of the Manger from White Horse Hill, above the Ridgeway. Note the almost total absence of tree cover in the area.
The Ridgeway has become so popular with ramblers and sightseers and even a minority of trail-bikers (not to mention cars and farm vehicles) that the Countryside Commission has employed a Ridgeway Officer to help administer the diverse demands placed on the area, and to establish guidelines for its users. The officer also organises a series of 'Downland Discovery' walks which, with different specialist leaders, touch on every aspect of the Ridgeway and its wildlife. The broad aim is to allow people to enjoy the Ridgeway in as many different ways as possible, while also protecting the traditional character of the place. There is little regimentation and much reliance on voluntary goodwill, so the feel of free passage along an ancient road still predominates.

Our 16km (10 mile) walk along the Ridgeway eastwards from Wayland's Smithy (west of Uffington) to the Robert Lloyd Lindsay monument near Wantage is, therefore, a unique trip through the collective history of Britain and, as such, brings into sharp focus the changes and pressures of our own bustling times, and their impact on the Ridgeway's landscape and wildlife.

Starting the walk–the monuments To start the walk, west to east, outlined here, the Ridgeway should be approached from the B4000. Where it crosses the Ridgeway, about half a mile west of Wayland's Smithy, parking space is provided. This, and other approaches, are given in *The Oldest Road: An Exploration of the Ridgeway* by JRL Anderson (published by Wildwood House)–a book which adds greatly to the appreciation of the journey. (Since the Ridgeway is a linear route, bear in mind that the finishing point is well removed from the starting point, so make arrangements to be picked up at the other end if you want to avoid walking all the way back again. One solution is to have two cars, with two groups of people, one starting at each end. When you meet in the middle, exchange car keys!)

Wayland's Smithy nestles in a grove of mature beech trees. Like many of the Ridgeway's ancient relics, the Smithy is layered in legend, being a long barrow or burial chamber dating from around 2800BC. The mile or so from Wayland's Smithy to Uffington Castle is a delightful track which first dips, then gradually climbs to White Horse Hill, the Ridgeway's highest point at 260m (856ft).

At first the track is open, with expansive views across arable lands; where once these supported sheep on downland slopes they now embrace acres of wheat and barley. Only the 15-20m (50-65ft) width of the Ridgeway is protected from the plough, but it is enough to avoid any real sense of being hemmed in. In spring and summer skylarks and lapwings are numerous here, while ungainly corn buntings flop, legs dangling, on to the crowns of hawthorn bushes to reel out their thin, dry song. Nearer Uffington, the track is girded with hedgerows of hawthorn, blackthorn and elder, interwoven with old man's beard. On a hot summer's day the hedges bristle with yellowhammers, chaffinches, whitethroats and spotted flycatchers. The hawthorns give some shelter from windblown fertilisers which have done so much to transform the once flower-rich swards into a uniform pelt of rank grass. Here in June germander speedwell, common vetch and black medick colour the banks.

Uffington Castle, an Iron Age fort, lies somewhat to the north of the Ridgeway and is well worth a diversion. Strategically mounted at the top of the northern scarp, the fort, its ditch and earthwork ramparts still grazed by sheep, commands an unsurpassed view of the Vale of White Horse below.

Nearby there is one of the area's most enigmatic monuments–the massive white horse etched in white chalk on the grassy scarp, with the Manger, a deep scalloped hollow, just beneath. Today Uffington is a National Trust property, visited by upwards of a quarter of a million people a year. The

Above: A chalkland specialist plant to look for as you walk along–the common rock-rose. Another immediate clue to the chalky soil in many places along this track is the countless *Cepea* snails which litter–and ornament–the banks. You'll find both empty shells and living snails.

Right: One of the many butterfly species to be seen on this walk is the attractive chalkhill blue. It is fairly localised in distribution but may be found in association with horseshoe vetch.

Below: Pyramidal orchids are locally common on and around the Ridgeway. They flower from June to August.

Above: The wayfaring tree (it is actually a shrub, not a tree) is an appropriate plant to find in the hedgerows bordering our route–it derives its name from the fact that it is so often found growing along chalky trackways.

Left: In a 'good' butterfly year you can expect to spot the marbled white on and around the path.

Below: In recent times the Ridgeway's sheep pastures were the traditional haunt of the stone curlew, but its numbers have now dwindled almost to extinction here with the advance of arable farming. However, you may be lucky enough to see one–the huge staring yellow eyes identify it at once.

erosion caused by so many feet at one time threatened to put a fifth leg on the horse, and to denude the castle ramparts, but with the aid of 1200 tons of topsoil and a scheme of enclosure and re-seeding, the battle against excessive trampling is being won for the present.

Chalk 'gardens' Behind Uffington is one of the few remnants of original chalk habitat left on the Ridgeway itself. Typically, these fragile patches cling to the steeper slopes and barrows left untouched by the plough. To chance suddenly on one of these natural chalk gardens gives a real sense of entering an oasis. In June and July they are a motley carpet of milkwort, yellow-wort, yellow rattle, wild mignonette and common spotted orchids. Elsewhere on and around the Ridgeway are such chalkland specialists as rock-rose, yellow carline thistle, clustered bellflower and autumn gentian. There are also several vetch species at Uffington and elsewhere, notably kidney and horseshoe vetches, sainfoin and bird's-foot trefoil, which are especially important to butterflies as foodplants. Among butterflies, the most characteristic are the various 'blues', which fly mostly in late June and July. A speciality is the chalkhill blue which, though fairly localised, may be found in association with horseshoe vetch in late July. Large, small and dingy skippers are much more common as also, in good years, is the marbled white. There is even the chance of discovering the Duke of Burgundy fritillary, attracted to the cowslips which are such a feature of the Ridgeway in late April and May.

Agricultural habitats The chalk flora, now confined to small enclaves, was until recently, the dominant habitat of the Ridgeway's flanks. Even before the advent of damaging artificial fertilisers it was already suffering from the loss of its strongest ally–sheep. In the Middle Ages the downs were open grazing for sheep and the Ridgeway was a drove road from Wales to the lucrative sheep and cattle markets further east. Steady grazing was the life-blood of the chalk flora, preventing taller vegetation from smothering the compact herb-rich sward. The regularity with which the name 'warren' appears in the communities bordering the Ridgeway also indicates the importance of rabbits in bygone days–not only to the domestic economy (rabbits were managed for their skins and meat), but also in maintaining the downland pastures by grazing.

Beyond Uffington the route again takes on a more agricultural flavour. Near Blowing Stone Hill deep ruts in the track tell of the impact of modern farm vehicles–greater than millennia of foot travellers. For all that, the switchback of the Ridgeway at this point harmonises well with the tramlines of growing barley. Nearing Sparsholt, the steep chalk rise

promises the largest patch of chalk flora on the Ridgeway, sheltered to the south by a gentle hawthorn-clad slope where the purring song of the turtle dove may be heard. In winter there is food and cover here for redwings and fieldfares and, in spring, migrant wheatears too. The grassy expanses, with their healthy vole populations, attract owls and kestrels.

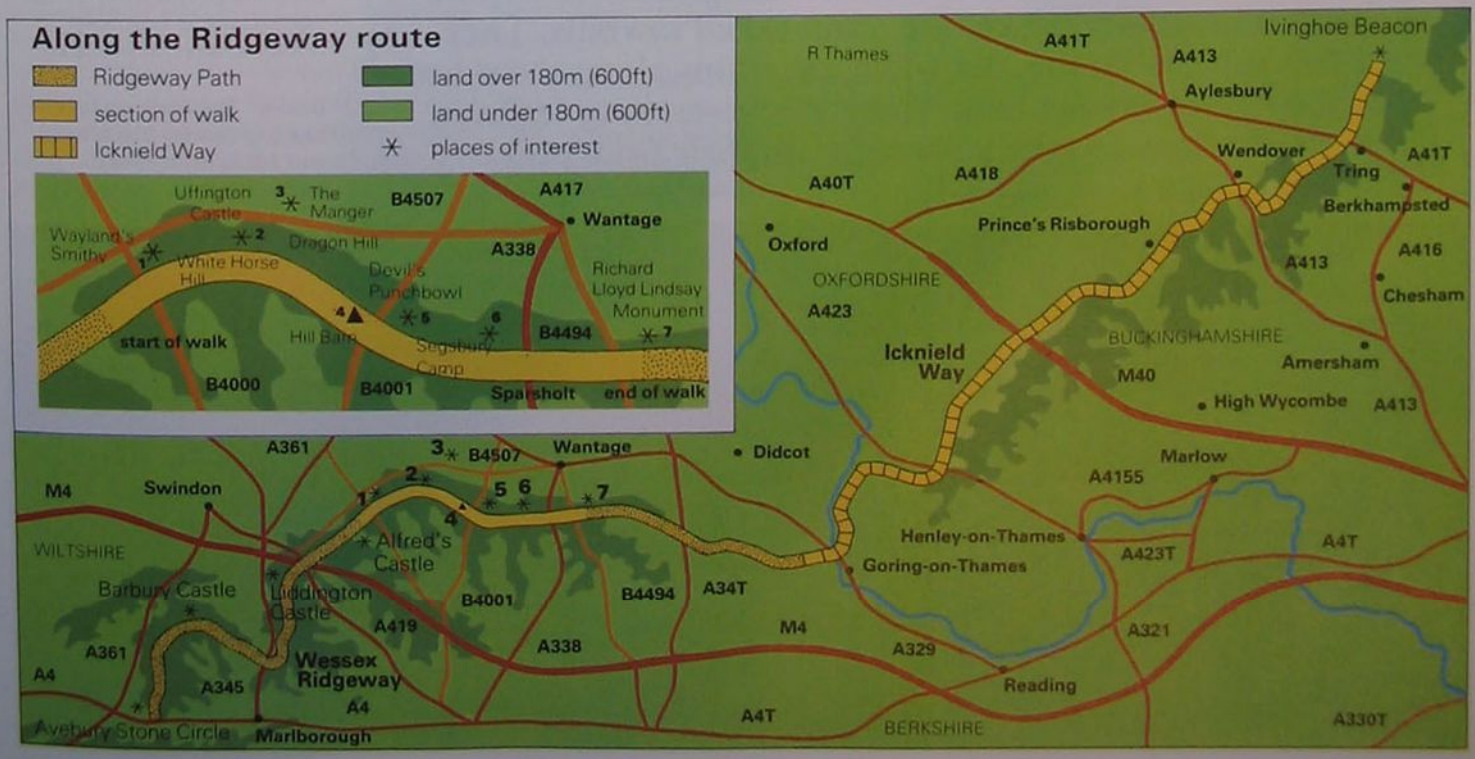
The final stretch Apart from small patches of hawthorn-dominated scrub, like the one at Sparsholt, and a few beech hangers and conifer plantations, the Ridgeway is conspicuously devoid of trees. The biggest woods, though they are by no means extensive, are near Uffington and Ashdown House. In such remnants oak and ash are dominant, providing shelter for fallow deer in small numbers.

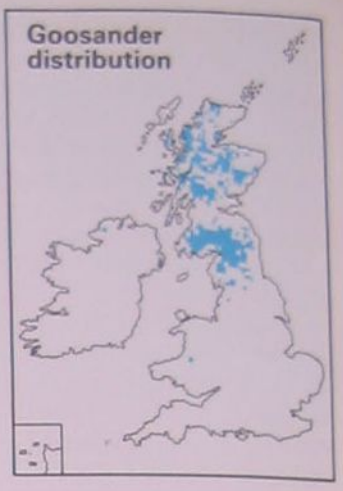
Beyond Sparsholt the track broadens out and is flanked by Gallops, a training area for the racing stables at Letcombe Bassett. To the left, deep curving contours cradle Crowhole Bottom and the Devil's Punchbowl–geological clues to a nascent river valley formed many thousands of years ago when either the water table was higher or the chalk froze, letting water flow over it. Now the track climbs quite steeply to a hedged section, bordered with campion, thistles, herb robert and speedwells. As the route nears its intersection with the A338, the Iron Age Letcombe Castle, or Segsbury Camp, appears on the left as a low grass and hawthorn-covered rampart.

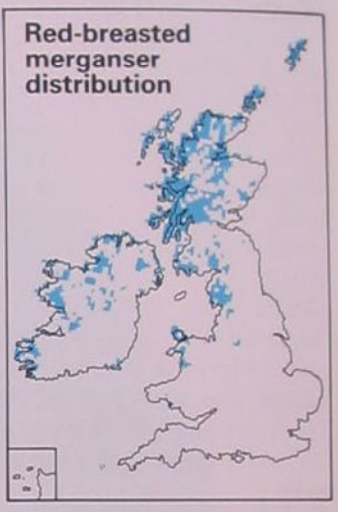
A dogleg to the right along the A338 brings you to perhaps the most rustic part of the walk, lined in May and June with cow parsley and alive with the sparrows, blackbirds, house martins and swallows that are attracted to the farm buildings. A small larch plantation, with some Scot's pine, provides songposts for corn buntings, while away to the left the massive cooling towers of Didcot's power station loom ever larger. A gentle slope brings you to the intersection with the B4494 and just beyond, where the Ridgeway opens into as broad and level a stretch as it ever becomes, our destination appears–the tall column comemmorating Robert Lloyd Lindsay, Baron Wantage, who died in 1901. The greatest landowner in the area, Lloyd Lindsay did much to shape the landscape here, planting many of the hedges and shelter belts evident today. From start to finish, monuments to two cultures 5000 years apart help to fix the Ridgeway as an abiding feature of a changing landscape.

Above: The chalky nature of the land underlying the Ridgeway is everywhere evident along our route. This view looks towards Wayland's Smithy in the distance; it is marked by one of the few clumps of trees found in the area.

Below: Our route covers 16km (10 miles) of the Ridgeway. This path and the Icknield Way together form one of the Countryside Commission's long-distance footpaths (136km/85 miles).







SAWBILLS: GOOSANDER AND MERGANSER

The goosander and the red-breasted merganser–two quite similar fish-eating ducks–are often called sawbills. They get this name from the tooth-like serrations along the sides of their long, narrow bills. These savage-looking features enable them to take a firm grip on their fishy prey.

Above: Both the goosander and the red-breasted merganser breed in northern Britain, but only the latter breeds in Ireland.

Above left: A female goosander, followed by ten young: she is probably fostering several broods.

Below: The male goosander has a greenish-black head and back, with white underparts.

The goosander is a large bird, about 65cm (26in) long, with a wingspan of up to 95cm (38in). The male has a black head, neck and back, with a glossy green sheen. His head bears a distinctive crest of feathers, and his long bill and his legs are reddish orange. His underparts are pure white, contrasting strongly with the head and back. The rump, belly and tail are grey. In flight, even more white shows, as virtually the whole of the inner half of the wing is white, with just a few black streaks; the outer half is black. The female is grey above and white below, with a chestnut head and neck, and a slight shaggy crest. In flight the rear half of her inner wing is white, and the forewing grey.

Arrival of a species Goosanders breed in northern latitudes throughout the Northern

Hemisphere. Rather confusingly, they are known in North America as common mergansers. It has been estimated that there are about 75,000 goosanders in north-west Europe, with between 900 and 1250 pairs breeding in the British Isles, mainly in Scotland. Yet the first definite breeding record of a goosander in Britain was as recent as 1871, when single pairs bred in Perthshire and in Argyll.

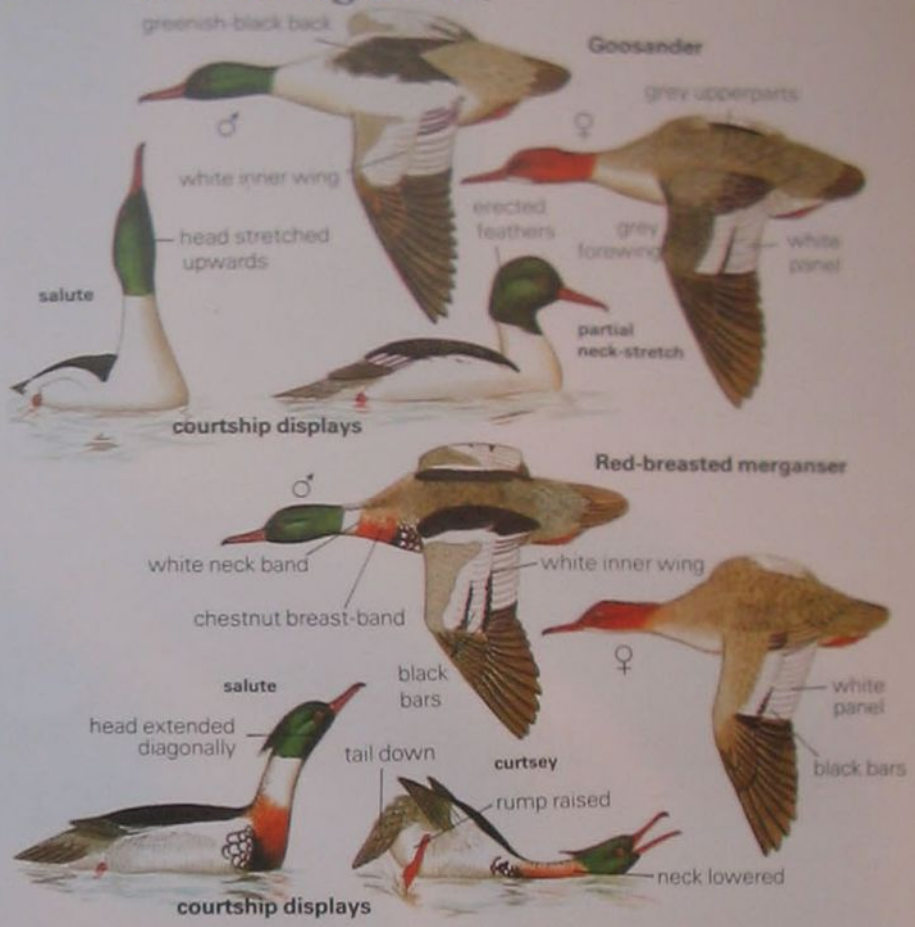
There had been rumours of breeding attempts earlier than that, in 1858 and again in 1862, but certainly the goosander was a rare winter visitor to Scotland before the 1870s. However, from about that time it became increasingly common, with winter influxes presumably leading to birds staying for the summer and breeding. By the turn of the century it had spread to most western Scottish counties, from Sutherland to Argyll, and was moving eastwards across the country.

During the first part of this century, breeding spread to the east coast counties of Aberdeen and Angus, and southwards to Renfrew, Selkirk and Dumfries. In 1975 it was estimated that there were up to 950 pairs in Scotland.

Summering birds were present in Northumberland from the late 1920s onwards, but it was not until 1941 that the first breeding record for England occurred in that county. The first nesting in Cumberland was in 1950, and during the next 10-15 years the birds spread south into County Durham, Westmorland and Lancashire, and bred in North Wales from about 1968. Today there are about 150 pairs breeding in Northumberland, with at least another 100 pairs in other English counties, and about 10 in Wales.

This increase and spread, welcome as it might be to birdwatchers, has been met with considerable opposition from fishermen, river bailiffs and others involved with trout and salmon fishing. It is claimed that goosanders cause great damage by taking young fish, and the birds are widely shot, although there is no direct evidence that they are harming the fish populations.

Two fish-eating ducks

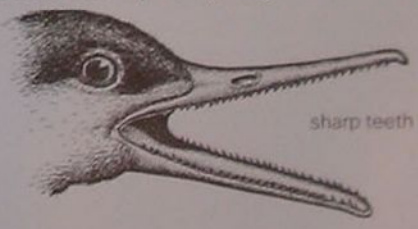


Goosander (*Mergus merganser*). Resident duck, nesting beside upland rivers and lakes. 65cm (26in).

Red-breasted merganser (*Mergus serrator*). Resident duck, mainly coastal. Up to 58cm (23in).

Below left: The red breast of the merganser is really bright chestnut, while the female goosander (below) has a chestnut head.

Both goosanders and red-breasted mergansers have serrated bills, with which they grip their catch. They feed on many fish species, mainly those between 10 and 20cm (4-8in) long.



Lakes and upland rivers Goosanders generally nest in holes in trees or banks, or among rocks, though they readily breed in nest-boxes and have used holes in buildings, from the cellar to the roof-space. The nest is usually within a few metres of water, though it can be up to a kilometre away. The female excavates a slight hollow within the selected hole, and lines it with whatever pieces of material or debris are within reach. She lays 8-11 eggs, and incubates them for about 30 days, the male taking no part in this, nor in rearing the young. The latter takes about two months.

Goosanders nest beside freshwater lakes, and along the upper reaches of fast-flowing rivers and streams. In winter they descend to the broader lower reaches, including estuaries, and also appear on reservoirs and gravel pits in small numbers. The principal food is fish, which they catch by diving, though they may first locate their prey by swimming on the surface with just the head and neck submerged. Underwater, they use only their feet to propel themselves, keeping their wings closed tightly. Dives can last for as much as two minutes, but half a minute is more usual, and they probably do not dive deeper than about 4m (2 fathoms).

The red-breasted merganser This duck is between 50 and 58cm (20-23in) in length, with a wingspan of up to 85cm (34in). The male has a black head, shot with green, ending in a ragged crest. His neck is white, contrasting with a broad chestnut breast-band. His upperparts are mainly black (with a green gloss) and grey, with grey flanks, though a broad white band shows on the closed wings. The underparts are white. The bill and legs are red. The inner half of the wing is white, but crossed by two black bars, and with a dark leading edge. The outer wing is dark.

The female is very similar to the female goosander, but has a larger shaggy crest and a duller chestnut head, and no sharp dividing line between the colour of her neck and breast. In flight, her wing pattern is more obviously barred black and white.

Expanding population The red-breasted merganser has a very similar distribution to that of the goosander, occurring all round the Northern Hemisphere, but extending further north, well into the Arctic. There are thought to be about 40,000 birds in north-west Europe, of which up to 2000 pairs breed in Britain.

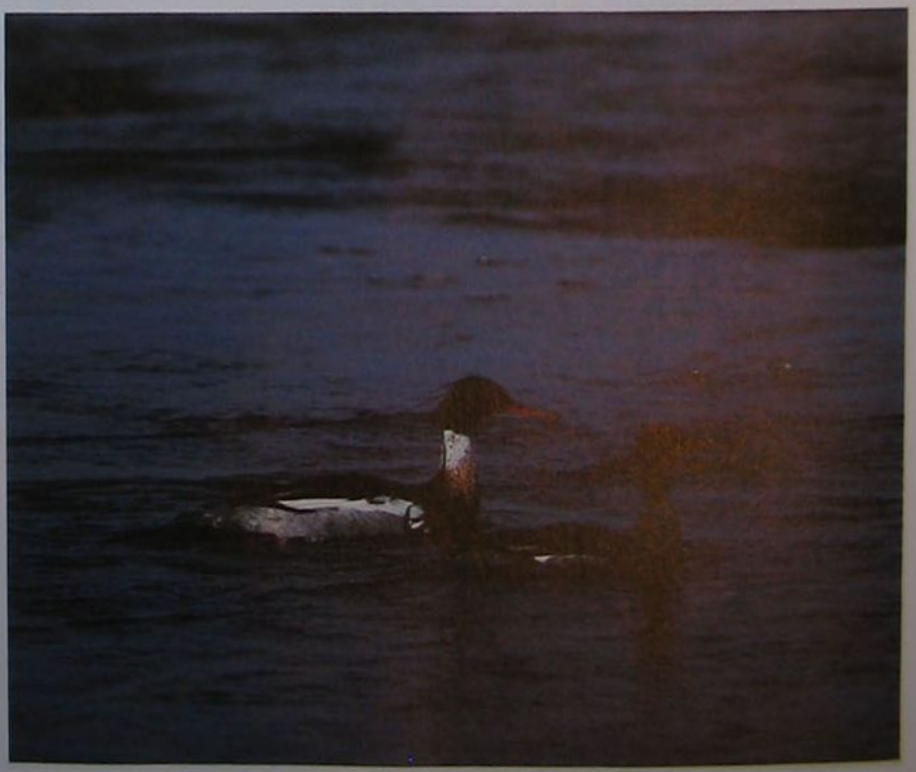
The red-breasted merganser has probably always been a British breeding species, but at the same time that the goosander was colonizing the country, it underwent a marked expansion, in both range and numbers, which is probably still continuing. It now breeds throughout the northern and western parts of Scotland, extending south through south-west Scotland into north-west England, where it first bred in 1950. It is now quite widespread in Cumbria, particularly in the Lake District, and has bred in North Wales since about 1953.

A coast dweller The red-breasted merganser is mainly a marine species, breeding around the coasts of Scotland, in sheltered bays and inlets as well as in estuaries. The birds also enter the lower parts of rivers, remaining separate from the goosanders, which breed in the upper reaches. During the winter they are found mainly on the sea, though sometimes occurring on inland freshwater lakes. Some large flocks are seen in certain estuaries, for example the Beauly Firth near Inverness, where up to 1000 have been counted.

The nest is nearly always on the ground, concealed in thick vegetation, or among tree roots or in hollows and crevices on banks and low cliffs. Small islands are favoured for nesting, presumably for added safety from predators. The nest is rarely more than a few metres from the water. The female scrapes a shallow depression and lines it with any available grass or leaves. In it she lays 8-10 eggs and incubates them for about a month. Neighbouring broods may amalgamate, some being cared for by a single foster mother.

Above: A male red-breasted merganser with his shaggy crest. Unfortunately, both goosanders and red-breasted mergansers are persecuted on Scottish rivers because they are believed to eat too many young trout and salmon. There is, however, little direct evidence of just how much damage the birds may be doing to fisheries. Despite extensive shooting, and destruction of nests, the birds continue to flourish.

Below: Red-breasted mergansers on the sea. They are almost purely fish-eaters, obtaining their prey by diving. Unlike the goosander, they use their wings to propel themselves, being one of the few species of birds that 'fly' under water.



TWO FINCHES OF OPEN COUNTRYSIDE

Two closely related finches of open land are the linnet, which is found on arable land and heaths, and the twite, which favours moorland and coastal areas. Both are brown, though in summer the males become enriched with patches of red.

Smaller and slimmer than a house sparrow, and in winter even drabber looking, linnets and twites fall into the group of 'small streaky brown birds' that give so many birdwatchers headaches when they try to identify them. To make matters even more difficult, they often flock together in coastal areas during the winter; and at this time of year the linnet may join up with the equally small, brown and streaky redpoll to form feeding flocks on farmland and rough ground away from the coast.

Crimson-patched linnets In summer, there is little difficulty in identifying the male linnet, for his breast and crown become a rich crimson–indeed, pinkish patches foretelling this are visible on the bird from the middle of winter onwards. The throat is whitish, the head greyish-fawn, and the back is a striking brown that verges on chestnut, a feature that remains a useful means of identification right through the year. The wing and tail feathers are dark brown, with the outer side of each being white, the amount of white increasing as the bird ages. In summer, male linnets are often seen perched on the top of a bush (gorse being especially popular), producing a pleasantly varied twittering song which lacks any formal pattern and may be just as varied in length as it is in pitch.

In early autumn, during its annual moult, the head and breast of the male revert to a speckled, nondescript brown, sometimes retaining a faint pinkish tinge.

The female linnet is, over all, a duller, more heavily streaked bird than the male, and lacks his pink or crimson patches. The young linnets resemble the female, though their background colour is sometimes paler and the streaking more pronounced. In the spring following their hatching, however, the young males begin to develop crimson patches as the breeding season approaches.

Feeding habits Like those other finches, the redpolls and twites, linnets feed on small seeds, in early summer often eating them well before they are ripe. At any time of the year, linnets may take advantage of a sudden flush of insects and feed on them. Whatever the state of the insect population, linnets feed them to their young in considerable quantities for the first few days after hatching, presumably because insects are richer in protein than plant foods.

Linnet distribution Linnets are widespread throughout much of England, Wales, Ireland and lowland Scotland. A few pairs are to be

Above: A linnet takes a bath. In 1972 the British population of this finch was estimated at between 800,000 and 1,600,000 pairs, which is on a par with the greenfinch and substantially more than the goldfinch.

Right: A female twite in summer, as shown here, is very difficult to distinguish from a female linnet. In winter, however, a twite's beak changes from greyish to yellow, a feature by which the two species can be easily separated.

found in the Hebrides and Shetland, the Highlands and the north-west coastal strip of Scotland. Eastern Scotland and the Orkneys, however, carry fair-sized populations. Linnets favour open, lowland habitats, particularly farmland and heaths.

The linnet is one of those birds that have adapted themselves well to our farming regimes. In Medieval times, when much of the country was wooded, the linnet would have been scarce, so it is one of the major beneficiaries of the way in which agriculture has opened up the British countryside. Things may, of course, change: linnets of farmland nest in hedgerows, a habitat threatened by clearance schemes, and they are also very dependent on weed seeds as a source of food in an age when weedkillers are being used more and more.

There are indications that, due to food shortages, the linnet population is beginning to suffer in the strawberry-growing regions of southern England. During the winter linnets, along with many other animals, steadily reduce the available foodstocks, but in the summer, when they might expect to feed on the new season's crop of seeds, the linnets are finding that these stocks are being depleted by weedkillers. So, in the early summer when wild foods are at their hardest to come by, linnets are turning to the strawberry crop, feeding on the small embedded pips. In some areas they are now regarded as pests and, where early strawberries are being grown under long polythene cloches, some linnet families have taken to living inside these tunnels. Here, they have abundant food and are safe from predators, the elements and the wrath of the grower.

Colonial breeding In the breeding season, linnets often nest in loose colonies consisting of anything from a few pairs to 40 or 50, each pair nesting a few feet from its neighbours. At this time of year the display flights of the male overhead are tunefully conspicuous, but as the season progresses he becomes quieter, often accompanying the female during nest building or while the young are being fed.

Above: A male linnet in its 'streaky brown' winter plumage. In summer its head becomes more greyish, its back a richer brown and its breast and crown develop a crimson patch. The beak of both male and female linnets is small for a finch, but has the distinctly conical shape typical of the group.

Below: The nest of a twite is always well concealed, either hidden among long grass (as here) or built low down in a bush.

The female linnet builds the nest–a neat structure of grasses and slender twigs, sometimes including moss, and usually lined with wool or hair. It is usually built in a bush, often a well-protected thorny one, rarely more than a few feet above the ground. The usual clutch is of four to six bluish eggs with brown spots and squiggles. These are incubated for ten to twelve days, mostly by the female.

For many pairs, two or three broods may be raised by the end of the breeding season in late August, shortly after which some of our linnets cross the English Channel and migrate southwards to Spain and the south of France, where they spend the winter. Not all the birds in a particular area migrate, however; hence the linnet is known as a 'partial migrant'. Those that do move have to run the gauntlet of Belgian bird-fanciers, who trap linnets in their thousands to sell as caged birds.

Introducing the twite Sometimes called the mountain linnet, the twite is easily confused with its close relative, especially with female and juvenile linnets. The twite is fractionally smaller, and an experienced eye can sometimes detect a relatively longer tail–a useful feature when looking at a mixed flock of the two species in flight in the winter. At this time of year, when perched or feeding on the ground, the twite can easily be separated from a linnet by its clear yellow beak. In summer, however, the beak changes to a greyish colour. Overall, twites are rather darker and more tawny-buff–sometimes the face and throat are almost orange. Given a good view, the

male twite can be seen to have a distinctive rose-pink rump (though it lacks the linnet's red crown and breast).

Often, it is much easier to distinguish twites from linnets by their calls. The 'chweek' or 'chwayeek' call of the twite is much more nasal and twangy than the comparable call of the linnet, and it is uttered frequently enough to be a very useful guide to the birdwatcher.

Birds of the steppes Most of the world's population of twites are found in the cold, high-altitude steppes of central Asia. It is thought that, as the ice retreated after the last Ice Age, some of these twites moved westwards, later to be cut off from the main concentration of twites and form the relic population that now exists in a narrow coastal strip extending from the north of Norway, south through Shetland, Orkney, the Hebrides and northern Scotland, down to north-west Ireland. The bulk of the British and Irish population is found along this strip, estimated to be between 20,000 and 40,000 pairs, which is about a fortieth of the total population of linnets. There are other pockets of breeding twites on moorland in Ireland and high on the spine of the Pennines in England, but the numbers in these areas are relatively very small.

Moorland birds The bulk of the British population of twites now breeds on the fringes of moorland, often near the coast and usually at low altitudes, contradicting the 'mountain linnet' image. In some areas, twites are present throughout the year. In other parts, however, the birds migrate, some to join Continental immigrants that fly to Britain to spend the winter on the coastal farmland, marshes and saltings of eastern and south-east England. Here they commonly mix with linnets, sometimes in large flocks.

Above: Linnet pairs share the job of feeding their young, bringing food to them both in the beak and also regurgitating some mushy seed material held in the throat. The young birds fledge about two weeks after hatching. Shown here with the young is an adult male.

Throughout the year, the type of food eaten by the twites, and broadly speaking their feeding behaviour, is similar to that of the linnet.

Late to breed The twite's nest is built low down in a bush or on the ground in long grass or among heather. Always well concealed and difficult to find, it is made largely of grass.

Twites breed as solitary pairs, or in loose colonies in the manner of the linnet. As would be expected of a northern, often high altitude bird, the breeding season starts late in the year and finishes early, the first eggs appearing in late May and the last fledgling leaving the nest in early August. During this time, some pairs of twites manage to raise two broods.

Below: The British and Irish distributions of linnet and twite show that the former is much more widespread.

Linnet (*Acanthis cannabina*). Resident finch of open lowland habitats. Length 13.5cm (5¼in).

Twite (*Acanthis flavirostris*). Moorland resident. Length as linnet.

THE MUDDY WORLD OF WATERWORTS

Among our smallest flowering plants are two species of waterworts that spring up suddenly and irregularly to colonize muddy lake-sides.

For such diminutive plants Britain's two species of waterworts have unimaginatively long and cumbersome English names: the six-stamened waterwort and the eight-stamened waterwort. Both belong to the same genus, *Elatine*, and botanists usually prefer to distinguish between the two species by their scientific names, *hexandra* for the six-stamened species and *hydropiper* for the eight-stamened.

Waterworts are small plants, rarely exceeding 10cm (4in) in length and usually considerably smaller. They are pioneer colonists of bare mud and silty sand just above and below the water's edge. When exposed to the air, or just lightly covered with water, the slender stems creep across the mud, rooting at every node (leaf joint). In deeper water, however, the plants assume a more straggly growth as the stems – which are only barely anchored in the lake bed – reach up towards the surface of the water.

Structure and life-cycle The flowers of both species are extremely small, no more than 3-4mm across. They are borne in the axils between the leaves and the stem from July to September. Flowers of *hexandra* have three delicate petals, while those of *hydropiper* have four. In both species, the petals are usually pale pink but may sometimes be white. Normally the flowers are self-pollinating, and if they are submerged in water they remain

Above: An unusually dry summer caused the water level of this loch in West Stirlingshire to fall and the exposed muddy fringe to be colonized by waterworts and other aquatic plants.

Below: As the exposed mud begins to dry out and crack, numerous small plants of eight-stamened waterwort appear on the surface. Not only is this mud organically rich, its dark colour readily absorbs heat from the sun, promoting rapid germination and growth.

unopened. Yet if the flowers are exposed above the water surface they may sometimes be visited by pollinating insects and cross-pollination occurs. Indeed, the flowers possess nectar-producing glands, which implies that the waterwort family was once terrestrial.

The seeds are small and weigh very little, so they are readily dispersed short distances by the flow of the water. Long-range dispersal, on the other hand, seems to be assisted by water fowl, the seeds becoming embedded in mud which then sticks to the birds' feet and feathers. The appearance and establishment of *hydropiper* at an Anglesey reservoir within 18 years of its being built almost certainly resulted from the seeds being transferred there by birds. Similarly, it is surely no coincidence that the six lochs in central Scotland where *hydropiper* has been found since its discovery at Loch Lomond in 1968 are all noted for their wildfowl populations.

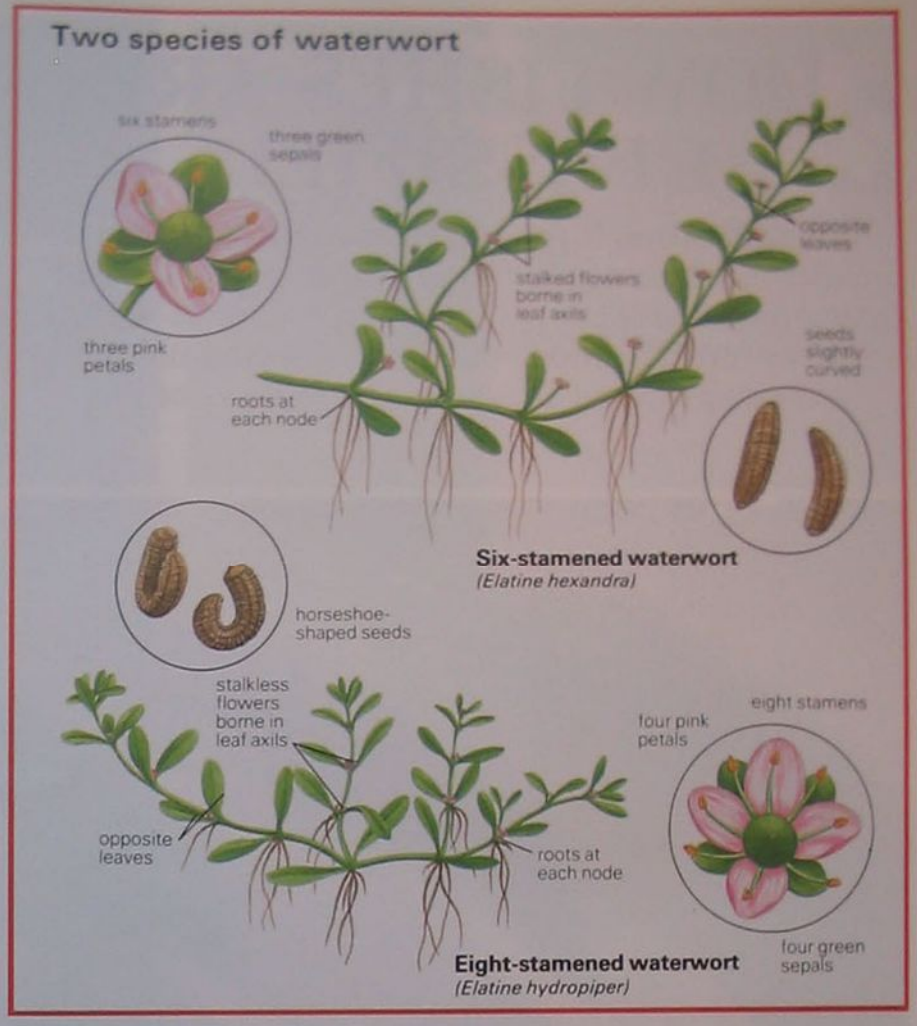
Once the seeds have become buried in the mud they can remain viable for many years, waiting for the right conditions in which to germinate: a fall in the water level occurring at the right time of year. As the intensity of light increases the seeds are triggered into germination.

Habitat and associates Waterworts are unable to compete for living space with the much larger perennial plants such as common reed and sedges, which follow in the wake of the first mud colonists. In Britain, these larger plants are sometimes prevented from becoming established around the edge of a lake by the effect of waves breaking upon wind-exposed shores. Another deterrent is farm animals trampling along the muddy fringes and the regular beaching of small boats on the shore. Both will erode the thickest aquatic plant growth, yet leave the tiny waterworts largely unaffected.

The waterworts' inability to compete with large aquatic plants is shared by other small or weak-growing inhabitants of the water's edge. Among the plants most often seen with *hexandra* and *hydropiper* are water purslane, common and autumnal water-starworts, needle spike-rush and shoreweed. A combination, or 'community', of several of these plants growing together in shallow water or on exposed mud is a good indication that one or both waterworts is growing close by.

Neither waterwort is found in lakes whose water originates in areas underlaid with limestone. In the nutrient-poor waters of the Lake District and the Scottish Highlands, only *hexandra* occurs. Conversely, *hydropiper* thrives at several sites moderately rich in nutrients. These are sites that *hexandra* seems to avoid though there is a definite overlap in the distributions of the two species.

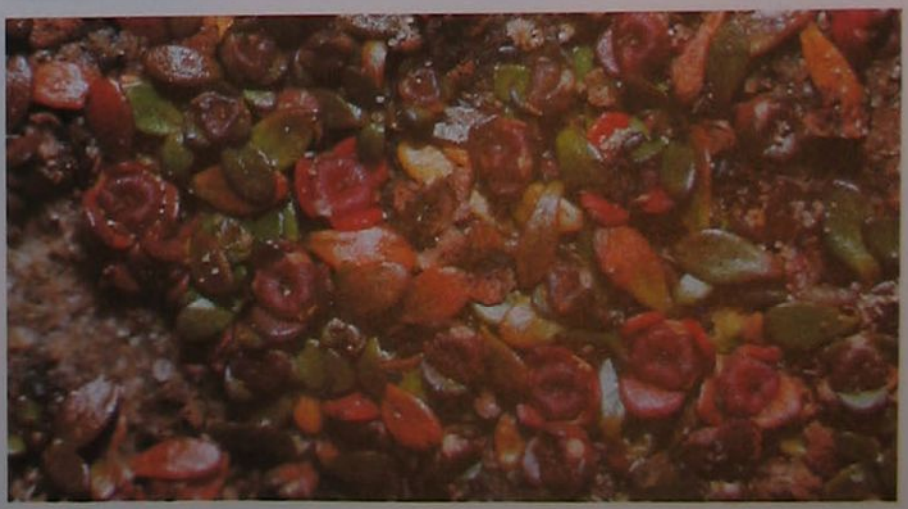
In Finland, and perhaps in other northern European countries, *hydropiper* grows in brackish water by the sea. The nearest example in Britain to this type of habitat is a small lake at the head of an estuary in north Wales, where *hydropiper* has been reported growing alongside the coastal species, beaked tassel-weed.



Above: A comparison of the six-stamened and the eight-stamened waterworts, showing differences in their flower structure and seeds.

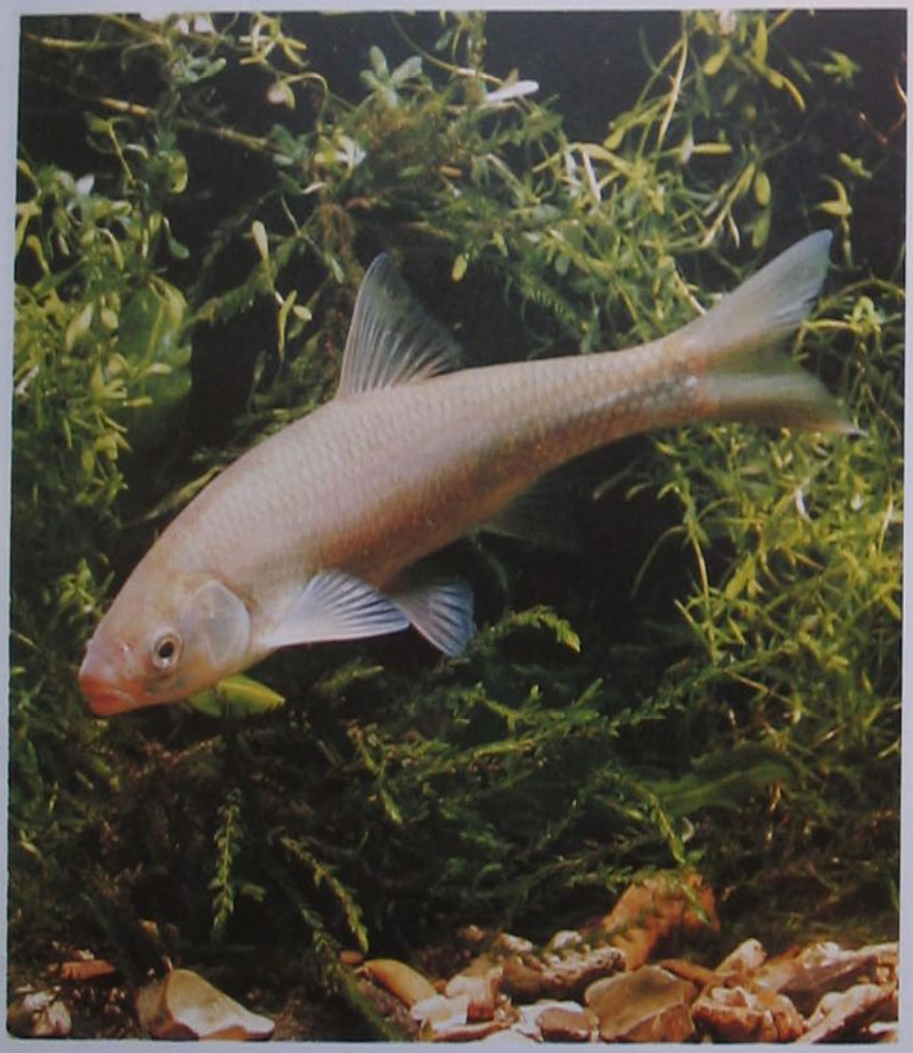
Below: With the aid of a hand lens the six-stamened species can be distinguished by the petals and sepals being in threes, the eight-stamened having them in fours. The normally green fruiting capsules and leaves of both species frequently turn red when exposed above the water line for any length of time.

The outlook A serious threat to the future of our waterwort colonies comes from agricultural fertilisers finding their way into lakes. Even the additional nutrients stemming from modern fish farms can be enough to tip the balance towards prolific algal growth, their dense mass near the surface of the water preventing light from penetrating to plants such as waterworts lying below. Experience, however, has shown us that we should never write off waterworts too soon, for they have a habit of reappearing unexpectedly in numbers at sites where they were presumed extinct.



HOW FISHES ARE CLASSIFIED

Classification is fundamental to most human endeavours, and is part and parcel of the work of naturalists. Modern classification separates British fishes into 23 orders–each one showing unique characteristics in structure and in ways of life.



Above: The dace is an example of the carp family. Together with the loach family, the carps comprise the order Cypriniformes. This order is virtually confined to fresh water, and it dominates some of our freshwater habitats–particularly the middle and lowland reaches of rivers, lowland lakes, canals and ornamental ponds. In this picture you can clearly see two typical features of the order–the fins lack spines, and the pelvic fins are situated well back.

To many people, it may seem that all fishes are alike, but the sea contains many biological surprises and a knowledge of the whole range of fishes reveals truly profound differences. These are reflected by the fact that the classification of fishes entails four whole classes. By comparison, other groups that form whole classes include birds, mammals, reptiles and amphibians. These four classes, and the four fish classes, make up the phylum of vertebrates.

Modern classification recognises two major groups of fishes living today. The first group, the jawless fishes, comprises two relatively small classes: the lampreys and the hagfish. Most fishes belong to the second group, the jawed fishes, which in turn comprises two classes: the cartilaginous and the bony fishes.

Fishes without jaws These are known as the Agnatha: their mouths are either a flattened sucking disc, or a slit with fleshy barbels on either side. They have virtually no skeleton other than a simple backbone of cartilaginous (gristly) vertebrae. They lack both pectoral and pelvic fins, and the other fins (anal and dorsal) are supported by thin strands of cartilage, but they are very poorly developed. They possess a single nostril, which is located on the mid-line.

As there are fewer than 100 species of jawless fish worldwide, Britain has a comparatively rich fauna with three lamprey species and one hagfish belonging to the group. The lampreys live and breed in fresh water, but two species–the sea lamprey and the lampern –migrate to the sea to feed. They are blood-sucking parasites on bony fishes, but the third species, the brook lamprey, is not a parasite. It has a long larval life of three years or so during which it lives buried in river mud and feeds on minute organisms at the mud's surface. The adult does not feed at all.

Jaws but no bones The cartilaginous fishes with jaws (a most distinctive feature in the case of the sharks!) have well-developed cartilaginous vertebral columns, which may be hard because of calcium salts that are deposited in them, but are not bony. Their cartilaginous skeletons are much more developed than those of the jawless fishes, and they possess pectoral and pelvic fins as well as a pair of nostrils. The males have claspers on the inner edge of the pelvic fins, which are used to transmit sperm to the female.

There are two groups within the cartilaginous fishes. The majority are in one group containing the sharks, skates and rays, which all have five to seven pairs of gill openings on the anterior part of the body. The second group contains the rat-fishes or chimeras, one of which is common at moderate depths off the Atlantic coasts of Britain and Ireland. Chimeras have slender tails, strong, rat-like teeth in their jaws, big fins and a strong spine in front of the dorsal fin.

The main group of cartilaginous fishes is divided into the sharks, which are slender-bodied fishes with between five and seven pairs of gill slits on their sides, and the skates and rays, which are flattened from above and have five pairs of gill slits (six in some species) underneath the body. In sharks, the main propulsive mechanism is the tail, the upper lobe of which is much longer than the lower because the spinal column runs along it. The pectoral fins of sharks are mainly stabilisers. In the rays and skates, the tail fin is greatly reduced, sometimes being a mere whip-like appendage with no fin at all. The rays and skates, however, use their very large pectoral fins for swimming.

Fishes with bones The third, and by far the largest, of the major groups is the class of

Above: Two pairs of fishes in which roughly similar looks mask wide differences in classification. The brook lamprey (top left) is a jawless fish, while the freshwater eel (bottom left) has a similar shape but is a jawed fish. The sting ray (top right) is a flat, cartilaginous fish, while the equally flat plaice (bottom right) has bones.

bony fishes. Perhaps 19,000 of the world's estimated 20,000 species of fishes, and 199 out of Britain's 235 species, are bony fishes. They have jaws, bony vertebrae and skeletons, usually both pectoral and pelvic fins, and paired nostrils.

Taken order by order, bony fishes among British species include the sturgeon, which shows a number of primitive features, and the herring, sprat and shads, which have the swim bladder connected to the inner ear in a unique manner. The eel order has a number of characteristic features, both in body and fin form; all species lack pelvic fins, and the moray eels lack pectoral fins as well. Eels also have a characteristic larval stage known as a leptocephalus.

In Britain, freshwater habitats are dominated by fishes belonging to two orders: the Salmoniformes and the Cypriniformes. The former, as its name suggests, includes the salmon, trout, charr and whitefishes, and also the pike, while the latter comprises the carp family (carp, tench, roach, bream, dace and others) and the loaches.

The codfishes (order Gadiformes), like the two latter orders, lack spiny rays in their fins, but have their pelvic fins closer to the head. In contrast to the carps, most members of the cod family are marine; the burbot, now possibly extinct, is the only British exception.

Britain's largest order In terms of numbers of species, most British fishes belong to the order Perciformes. All these have spiny fins, pelvic fins placed well forward towards the head and rough-edged scales. They include the freshwater perch, ruffe and zander, and the marine bass, wrasses, mackerel and tunas, gobies, blennies and red and grey mullets. A related order is the Scorpaeniformes, which includes the gurnards, bullheads and sea scorpions.

The only other major group in Britain is the order of flatfishes, which are highly specialised for life on the sea-bed, lying on one side rather than on their bellies like the rays. They are thought to be derived from ancestors of the Perciformes and show a very advanced degree of adaptation.

Below: The red mullet is one of 79 species in the Perciformes, Britain's best represented order of fishes.

British fish classification

1 Lamprey

2 Hagfish

4 Porbeagle shark

3 Six-gilled shark

23 Sun-fish

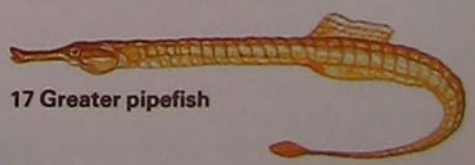
22 Plaice

21 Two-spotted clingfish

Super-class	Class	British orders	
AGNATHA jawless	Cephalaspidomorphi	1 Petromyzoniformes	lampreys
	Pteraspidomorphi	2 Myxiniformes	hagfish
GNATHOSTOMATA jawed	Chondrichthyes	3 Hexanchiformes	primitive shark
		4 Lamniformes	sharks
		5 Squaliformes	spiny sharks
		6 Rajiformes	rays and skates
		7 Chimaeriformes	rat-fish
	Osteichthyes	8 Acipenseriformes	sturgeon
		9 Clupeiformes	herring, sprat, shads
		10 Anguilliformes	eels
		11 Salmoniformes	whitefishes, trout, pike
		12 Cypriniformes	carps, loaches
		13 Gadiformes	codfishes, hake, eelpouts
		14 Lophiiformes	angler fishes
		15 Atheriniformes	garfish, sand-smelts
		16 Zeiformes	dory
		17 Syngnathiformes	pipefishes, sea-horse
		18 Gasterosteiformes	sticklebacks
		19 Scorpaeniformes	scorpion-fishes, gurnards
		20 Perciformes	perches etc
		21 Gobiesociformes	clingfishes
		22 Pleuronectiformes	flatfishes
		23 Tetraodontiformes	sun-fishes, triggerfishes

TOTAL

20 Perch



17 Greater pipefish

18 Three-spined stickleback

19 Bullhead

5 Spurdog

6 Roker

7 Rat-fish

8 Sturgeon

9 Herring

10 Freshwater eel

11 Salmon

12 Carp

13 Cod

14 Angler fish

15 Garfish

16 Dory

Number of British Families	Number of British Genera	Number of British Species
1	2	3
1	1	1
1	1	1
4	10	11
2	2	2
3	3	17
1	1	1
1	1	1
2	5	6
2	2	2
4	7	9
2	11	14
4	17	24
1	1	2
4	4	4
2	2	2
2	5	8
1	3	3
5	12	14
20	47	79
2	4	7
3	17	21
3	3	3
71	**161**	**235**

Fishes of the British Isles

This chart shows fishes native to Britain and Ireland, occurring either in fresh water or in the sea within 100m (50 fathoms) depth. If the limit were set at 1000m (500 fathoms), some 130 more species would have to be added to the chart.

The sequence
The groups are listed in an order which is not random but specially designed to represent as closely as possible the progression from primitive to advanced. Thus the lampreys are the most primitive fishes, and the sun-fishes are the most advanced.

Class status To place the lampreys and hagfish in classes of their own may seem to be according them undue importance, as if to put them on a level with the well-known classes such as birds, mammals or insects. But among invertebrates there are several other examples of relatively unimportant groups with class status.

HOUSE CLIMBERS

In the wild, trees and hedges are the main supports for climbing plants but, in their different ways, climbers are just as capable of scaling the walls of a house.

Above: Among the most beautiful of all climbing plants when in flower is wisteria, here seen clothing the front of a house. The flowers appear in May and June before the foliage has opened fully, wisterias being deciduous. Borne in long pendulous clusters, the flowers have the typical structure of plants in the pea family, of which wisteria is a member.

Right: Climbing hydrangea growing up a tree stump. Like ivy, this plant grows unaided up walls as well as trees by sending out aerial roots to penetrate the supporting structure and anchor the plant. However, climbing hydrangea is a much less tenacious plant than ivy. Its heads of white flowers appear in June.

Despite their initially unpromising, even forbidding, appearance, brick or stone walls provide an excellent habitat for plants. Old walls with their crumbling brickwork and missing mortar can be colonized by a variety of species, nooks and crannies providing plenty of access for probing roots and the soil accumulated there being able to support quite large plants. However, where the walls are new and relatively smooth or well maintained, small plants cannot establish themselves–but climbing plants can. Indeed, people often plant climbers on the outside of their houses to clothe the brickwork and add colour or interest to an otherwise dull surface. To scale the heights of a wall lacking any easy footholds, climbing plants have developed a number of different techniques.

Anchoring aerial roots One of the most expert 'mountaineers' among climbing plants is ivy, the other being Virginia creeper. Both can climb to great heights up vertical surfaces completely unaided, using very different means of support.

Ivy has strong flexible stems which become woody and often very thick with age. These stems produce numerous aerial roots whose fibrous nature gives them the appearance of fringed ropes snaking upwards. The aerial roots penetrate a short way into the wall –especially into softer mortar–firmly anchoring the stem along its entire length and sometimes causing great damage to the wall.

The aerial roots of an ivy are produced only by sterile juvenile stems. When the plant reaches the top of its support (the top of the wall, in this case) it develops flower-bearing fertile stems, which lack aerial roots.

Another climbing plant that clings to the wall in a similar manner to ivy is climbing hydrangea. Its broad leaves and loose heads of white flowers are similar to those of the familiar shrubby hydrangeas, but instead of forming a domed bush this species is a vigorous climber, the stems sometimes reaching as high as 25m (80ft). As well as growing upwards the stems also grow horizontally, which makes it an ideal plant for covering large high walls. Unlike the evergreen ivy, climbing hydrangea is deciduous and looks dull and untidy in winter. However, the reddish tints of the young leaves and shoots in spring, and the magnificent panicles of white flowers in the summer, more than make up for this.

Virginia creeper One of the most popular house-climbing plants in Britain is the Virginia creeper. The name has been given to a

number of different species, most commonly *Parthenocissus quinquefolia*. This North American native has rather insignificant flowers and is grown for its vivid display of autumn colour. Like both ivy and climbing hydrangea, it is a vigorous, self-supporting climber capable of covering an entire house, but its method of climbing is entirely different. In the axil of each leaf is a short, branched tendril, each branch ending in a disc-shaped adhesive pad. These pads act as suckers, literally sticking the plant to the wall so that, even if the stems are cut through at ground level, the plant remains in place.

Virginia creepers do little damage to the surface of the wall, though they can become a nuisance if they penetrate into the eaves or guttering since the stems are almost impossible to move once they get a grip.

Stem twiners A number of climbers, if they are to make their way up a wall, need the benefit of a suitable framework, such as a trellis, wires or a pergola. Most are twiners, different species having adapted different organs for hanging on to the framework. Many use their stems, notably wisteria and honeysuckle. Both plants, when young, produce flexible stems that twine over and around their supports. With age, however, the stems become woody and rigid; very old wisterias may even become self-supporting.

Some stem climbers twine around their supports with random twists and turns, while others always grow in a particular direction. Hops, for example, always grow in a clockwise spiral (looking down at the plant from above) and bindweed grows in an anticlockwise spiral. Morning glorys grow in the same manner as bindweeds, and are closely related to them.

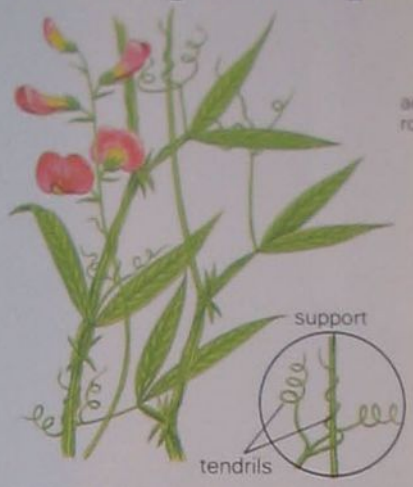
Perhaps the most vigorous stem climber is Russian vine, or mile-a-minute plant, so-called after its sometimes astonishing rate of growth. It can reach up to a height of 12m (40ft) and covers walls, buildings and trees quicker than any other climber.

Tendril and leaf climbers Grape vines, sweet peas and several other plants use clasping tendrils to fasten on to a support. The tendrils of a grape vine are negatively phototropic –that is, they grow away from the direction in which light is strongest. Therefore, when a grape vine is climbing up a wall, its tendrils naturally grow towards any crevices in the wall or support. Once they have entered the darkness the ends of the tendrils swell and become sticky to form pads similar to those on the Virginia creeper, which is a related plant.

One group of plants–the various species of clematis–use their leaves to provide support. The leaves are divided into various numbers of leaflets and it is actually the petiole (the stalk of the whole leaf) that twines around the support.

Climbing roses Among the commonest plants growing against houses are roses. Unlike other climbers, roses have no organs specifically adapted for climbing, but the strong thorns on the stems play a large part in providing support. Although they are weak climbers, roses can grow to a height of 15m (50ft) given the right support. Some produce fairly stiff growth capable of self-support, while other less vigorous roses can only grow up posts or over pergolas.

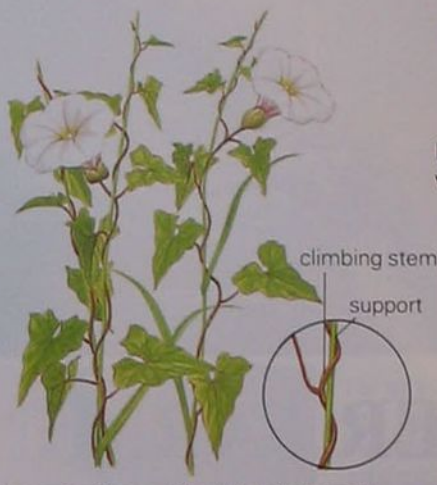
Climbing techniques



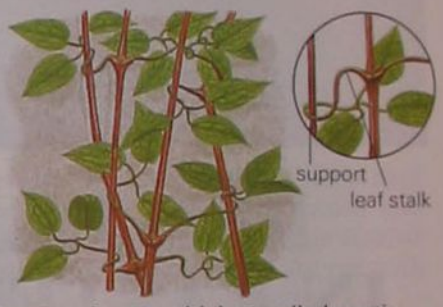
Tendril twiners such as sweet pea have thin wire-like tendrils that clasp nearby supports.

Adhesive climbers like ivy cling on with aerial roots or sucker pads.

Roses climb by their curved thorns, which hook on to the support.



Stem twiners like this bindweed wrap themselves around the support as they grow upwards.



Leaf twiners, which are all clematis species, hang on with their leaf stalks.

Above: Five different ways of scaling a wall.

Below: The name Virginia creeper is given to several distinct species of climber. Shown here is *Parthenocissus tricuspidata*, in typically brilliant autumn colour.

RED DEER FARMING IN EASTERN SCOTLAND

Red deer farming is an increasingly successful agricultural practice. John Fletcher explains how he established his now thriving 80-acre farm in Fife, Scotland, ten years ago, and his changing work through the seasons; and Ed Rattray discusses how deer have been domesticated by man over the centuries.

Above: Red deer in the habitat we most closely associate with them: the seven million acres of moorland and mountain in the Scottish Highlands. However, red deer did not always live in remote areas of the British Isles: they were driven there as our forefathers cultivated the land and claimed it for settlements. Even in these 'wild' areas there is simple management and control of the deer.

When I first thought of farming deer, it all seemed simple. I had just spent four years of full-time work watching red deer, both wild and tame, and believed I knew it all. Now ten years later I am a little more humble but have at least achieved a system that seems to work.

In the beginning The nucleus of my herd was to be those animals I had come to know by name during research work on the Isle of Rum. They arrived, to the astonishment of the watching summer tourists, anaesthetised on the deck of a small fishing boat as there was no landing stage on the island.

In the first winter I fed them alongside cattle and was puzzled to find that in a shower of sleet, rain or snow they would be the first to abandon the hay and run for shelter. I also soon found that deer calves quickly succumbed to the cold eastern Scottish winter. The next year I enclosed some woodland and a deep gully to provide shelter from the wind, and increased the winter ration for the adults to a daily 2kg (5lb) each of hay and potatoes. Finally, I resorted to housing the calves; my fears that they would pine away in an unfamiliar building were allayed when I saw them tearing around the shed playing each evening while those outside huddled miserably. Later, work at the Rowett Research Institute in Aberdeen proved that deer are actually less well insulated than cattle and sheep, and it brought home to me the fact that deer only live in the Highlands because man has driven them off the more productive lower ground. They only survive because they are adept at finding shelter.

Right (middle): A young red deer calf. All the venison on John Fletcher's farm comes from deer less than three years old and is therefore much more tender than meat from older, wild animals.

Right (bottom): Caring for the deer throughout the long winter is hard work as they must be given daily rations of hay and potatoes. They live on this diet, supplemented occasionally with cereals, for seven months or more of the year.

Above: A red deer calf lies beside its mother minutes after its birth. The calves are born from late May until the end of June. They start nibbling at grass within days of their birth, although they are also suckled until Christmas.

Right: In early May before the deer are turned out on to the new grass they are gathered and injected to kill any parasites. They are treated again in September.

Eventually I came to adopt a particular yearly routine. When the grass finally emerges in mid-May the adults are run through the yards, injected to kill any parasites, and segregated into stag and hind groups. Likewise the calves are turned out: stag calves joining the adult stags and hind calves joining the hinds. During the summer they are rotated from field to field to maximise usage of the grass, but 12 hectares (30 acres) are not grazed until hay has been cut for the next long winter.

The first calves arrive in late May and by the end of June the births are almost over. Calving troubles are rare, and I believe in leaving the hinds to give birth in peace and tranquillity as far as possible. Then in September all the deer are gathered again: calves are weaned and housed and all stock are once again treated against parasites. Selected stags are put with groups of about 40 hinds for the rut.

A roaring success For me, this extraordinary event, the rut, still summons memories of the wild deer on Rum as, for about three weeks, the stags lose their appetite, chivvy the hinds and above all, roar. This sounds rather like a lion's roar, carries well on a quiet evening, and represents a substantial output of energy when it is repeated every few minutes. It is actually a means of assessing opposition when a competitor approaches a stag and his harem. The antlers, secondary sexual characteristics under control of the sex hormones, are grown in red deer through the summer before being cleaned of their furry skin–the velvet–and hardened for use against competing stags in the autumn rut. Strange, elaborate weapons of offence and defence, they act as deterrents but, like all deterrents, can only work if they can be used; on Rum antler injuries affect about 23% of the adult stags each year.

On our farm we have to saw the antlers off before the rut to stop the stags injuring each other; if we let them, they would eventually drop off naturally next spring. Fortunately, removing the antlers is not more painful than cutting one's toenails and does not appear to demoralise the stags when all the antlers are

Above: John Fletcher injecting his deer to kill any parasites, the most unpleasant of which is the warble fly which causes discomfort to wild deer.

Below: A view of John Fletcher's farm in Fife, where his vigilant feeding of the deer throughout the long winter makes the animals very tame. He says: 'I like to think of my farm as a latter day deer park, and I dream that once more we will have 2000 deer parks in Britain'.

cut off together.

Winter care The rut is suddenly over, the bigger stags will by now have lost a fifth of their body weight, and winter is upon us. In the sheds the calves thrive on hay and potatoes, perhaps supplemented with some cereals, while outside the adults' metabolism slows down. They no longer expend energy in play but conserve themselves for an ordeal which in some Scottish deer forests may kill half the adults and a quarter of the calves during a bad winter. Among our deer, hay and potatoes now keep mortality down to only 1% among adult deer, although when we buy in wild stock from the Highlands losses may be higher. Such wild deer are often in quite poor condition and always arrive with that burden of the wild Scottish deer–warble fly larvae. This fly lays its eggs on the deer in spring; the larvae enter through the skin, circulate to the back of the animal and emerge in February and March as inch-long white maggots. Most wild deer carry at least 20 of these and the worst affected have over ten times that number. Thankfully, our treatment on the farm rids them of this horror.

During early winter I have to carry out the most unpleasant job of all–killing them for the consumer market. I believe that shooting the deer on the farm is the most humane death I can provide and I am not one who would enjoy sending off my stock alive on a lorry. Somewhat disconcertingly, the deer seem quite unconcerned at the demise of their fellows and will be feeding within inches of their dead comrades in minutes. This allows me to shoot three or four animals once or twice a week and carry out the butchery with minimum staff and disturbance. The meat is cut into joints, packed in polythene bags, frozen and sold through our little farm shop so the system is entirely self-contained and the animals need never leave the farm. Evidently our customers appreciate the tender farm produce, so different from the wild venison which may often be from animals of ten or more years old shot from many yards away and then carried extremely laboriously to the game larder for hanging.

Venison

Deer farming has a long history. Neolithic man certainly hunted deer; the Greeks and Romans had deer parks, and in England by the 14th century almost 2000 deer parks were being managed to provide sport and meat. Improved agricultural techniques in the 17th and 18th centuries, especially in cattle and sheep breeding, led to a gradual decline in the importance of deer as a source of meat and by the end of the 19th century there were only about 300 deer parks, maintained primarily for their picturesque value. Deer stalking and shooting became a favourite pastime of the rich, with venison production being only a sideline. This interest in stalking also meant the deer were not hunted to extinction but protected, and laws were passed by Parliament to restrict stalking and shooting during spring and summer–the close season.

The decline in deer park populations continued this century until the early 1970s. The Hill Farming Research Organisation and the Rowett Research Institute, both based in Scotland, wanted to find new ways of farming poor land in the Highlands and a team of physiologists, nutritionists and vets set about looking at red deer in a scientific way. Some important facts were discovered. For example, although deer have only one offspring each year, during summer plenty young deer can grow even faster than sheep, gaining as much as 400g (14oz) in weight each day–a great bonus to the farmer who wants to produce meat cheaply. It was thought that deer would be difficult to domesticate and that their fear of man would be carried from one generation to another, but this has not been the case; even hinds born in the wild soon settle into large grass paddocks enclosed by 2m (6½ft) high mesh wire and accept the presence of their handlers. The stags present a different problem, even a danger, and the commonsense rules of stockmanship which apply to bulls must also apply to stags.

Many farms are on good quality lowland pastures, with the foundation stock animals captured as adults after being shot with tranquilliser darts or simply herded into the yard. It is illegal to take wild deer calves into captivity, but when this was done under NCC permit at the Rowett the hind calves were bottle fed and grew to be quiet and docile, even accepting handling by the farmer.

With better feeding and modern veterinary techniques, larger animals are already being produced, and with further selection it is hoped to advance the breeding age and the breeding season. This will mean that deer calves which are normally born in the wild during June or early July could be born in May on lowland farms. They would then be at their fastest growing stage in life when the summer flush of grass was available. In this way, just as in sheep husbandry, animals born in spring can be large enough by October for the farmer to sell to the butcher.

Over the next 10 years venison is likely to become available in increasing quantities in Britain. The British Deer Farmers Association is pioneering systems which will introduce venison as an attractive, high quality lean meat in our supermarkets. At present some 100 deer farms are selling meat to the public at the farm gate and to hotels and restaurants. The quantity of venison available is still small and can be measured in tens of tons. In fact, if all the venison presently available, both wild and farmed, was sold in Britain, it would provide only 28gr (1oz) of venison per head of our population per year. With earlier calving and rapid summer growth, deer farmers will eventually be able to produce enough venison to satisfy the growing demand. It will take time, but all the signs are that venison will become an everyday alternative to lamb, pork, beef or chicken–and, let us hope, at prices which everyone can manage to afford.

Above and below: Deer farming at the Rowett Research Institute in Scotland. Deer are intelligent animals which readily accept a degree of control. The hinds settle quickly, learning to live with the noise of vehicles or even low flying aircraft, and in many cases the herds of deer will come to the handlers when called or whistled. Something unfamiliar, however, can make them nervous–even a regular deer handler will be treated with suspicion if he or she appears in unfamiliar clothing. The stags present a different problem, even a danger, and have to be approached with great care, as you would a bull. The hinds in particular are curious by nature and will quickly learn to approach humans to nudge, smell and explore. Nothing is safe from their attentions and they will nip articles from pockets, chew notebooks and even pull the wires off a stationary tractor, given half a chance.

THE PEMBROKESHIRE NATIONAL PARK

The Pembrokeshire National Park is largely a border of land winding round a tortuous coastline, but there is also an upland region in the north-east, where the boundary turns inland to include the Preseli Hills which enjoy wide views over the sea to Devon, Snowdonia and occasionally even Ireland in the west.

The great cliffs and rocky islands of Pembrokeshire, thrusting out into the Atlantic, form the south-western peninsula of Wales. *Penfro* is its ancient Welsh name, meaning 'Land's End', and *Penfro* has long since been anglicised into Pembroke. In several ways the Pembrokeshire Coast is unique among our national parks. It is the smallest, at 580sq km (225 square miles), the most maritime and also the most lowland, much of it being below 60m (200ft). With 820mm (32in) on the west coast, it also has the least rainfall of any park. In addition it has the mildest climate and a greater proportion of arable land.

A look at geology Beginning at the Preseli Hills, you will find yourself in a peaty moorland world dominated by masses of heather and grassland. Some of the underlying rocks are Ordovician slates and shales, but there is also much igneous rock standing up as huge isolated piles of mountain-top detritus and forming a very strange, almost moonscape type of scene. These hard igneous rocks continue from the Preseli Hills to the north coast to build up massive cliffs and promontories from Strumble Head west to St David's Head. Up the coast north-east of Strumble the headlands of Dinas and Cemaes are of Silurian sedimentary rocks.

In the far west the cathedral city of St David's–really only a village–is built on Pre-Cambrian rocks, but the purple stones of which the cathedral is largely built were quarried in the Middle Ages from Cambrian rocks near the sea cliffs to the south; these rocks form a rugged coastline from there for

Below: A view of Westdale Bay, on the Pembrokeshire Coast Path–you can see thrift growing along the top of the cliffs. The varied coastline of the Park, with its strong tides, is extremely irregular in shape and its many rock types and estuarine sands and muds provide a wide range of habitats for marine and shore life. The sea all around is rich in fish and the intertidal zone teems with invertebrates. Three bodies are directly involved with wildlife protection in the Park: the Nature Conservancy Council, The West Wales Naturalists' Trust and the RSPB. The NCC's reserves are at Skomer and Stackpole, the WWNT has reserves at Skokholm, Dowrog Common (St David's), West Williamston (Cleddau Estuary), Gwaun Valley and elsewhere, and the RSPB owns Grassholm. For information apply to: NCC, Plas Gogerddan, Aberystwyth, Dyfed; WWNT, 7 Market St, Haverfordwest, Dyfed; RSPB, Frolic St, Newtown, Powys.

Left: An adult slow-worm sun-bathing. The Park's other reptiles are the common lizard, the adder and the grass snake. Of these, the slow-worm is probably the commonest. The lizard reaches the highest ground (half-way up the slopes of Preseli), while adders are local on the heaths and sea slopes. The grass snake is restricted to sheltered inland places, usually near water. Frogs, toads and palmate newts are all widespread on the mainland. On the islands the distribution of reptiles and amphibians is patchy.

several miles to the deep sheltered inlet at Solva. There the Cambrian rocks end, where the ocean has carved St Bride's Bay out of the much softer Coal Measures to produce a shore of sands and cliffs that continues south for six miles to Little Haven.

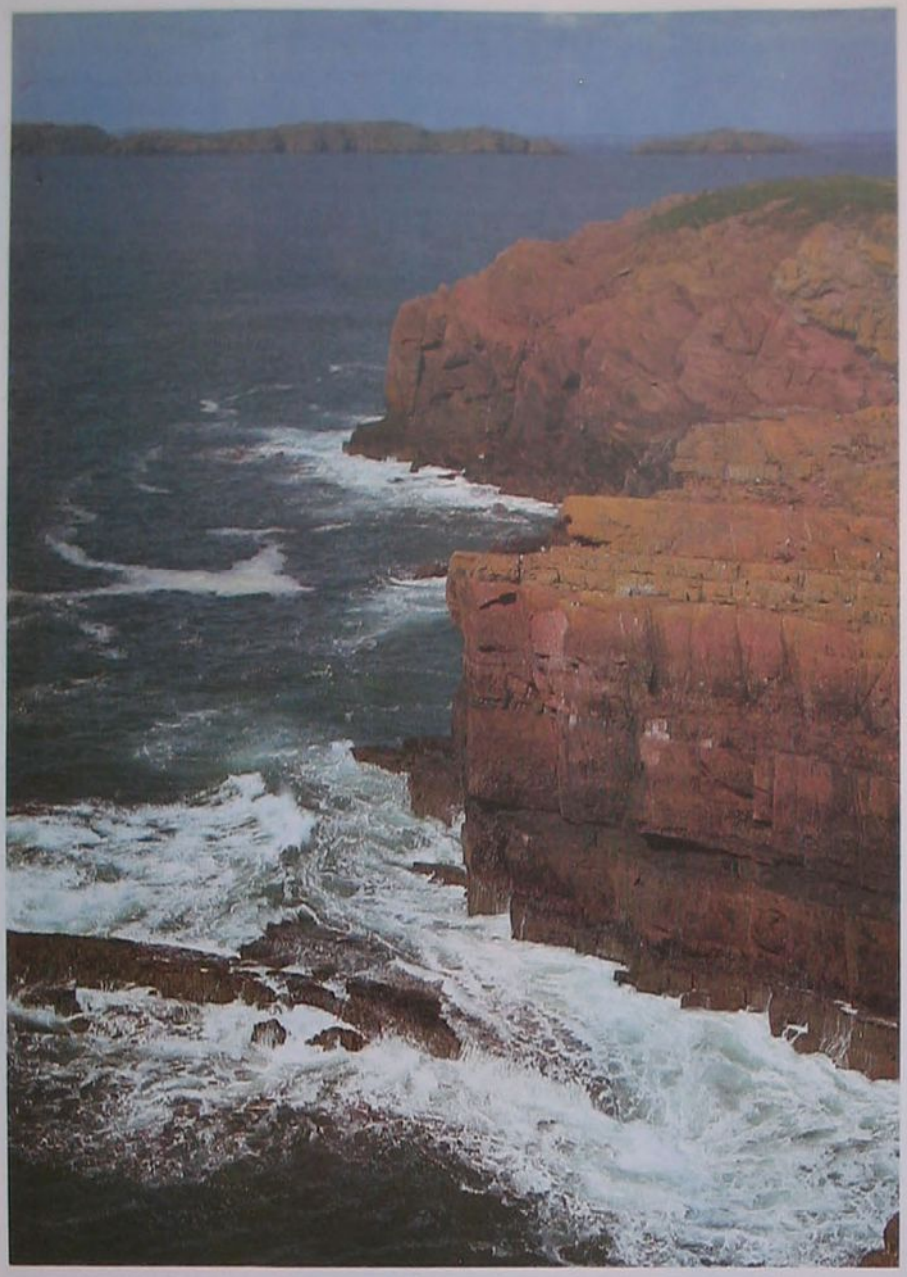
The southern arm of St Bride's Bay is made up of Devonian rocks (Old Red Sandstone) which form most of the land on both sides of the deep inlet of Milford Haven, including the bold wind-swept promontory of St Ann's Head. But the Old Red Sandstone is interrupted around Marloes by a band of Silurian rocks which are volcanic at Wooltack Point and sedimentary along the back of Marloes Sands.

The south coast of the Park begins in the west with a magnificent line of Carboniferous Limestone cliffs, stretching eight miles from Linney Head to Stackpole Head. A famous feature here is the Green Bridge of Wales, a great column of limestone standing in the sea and connected with the main cliff by a natural arch that will one day collapse to leave an isolated pillar like the Stack Rocks nearby. From Stackpole the cliffs, which continue east to Tenby, are alternately limestone and sandstone. Then beyond Tenby, where the coast turns north, the cliffs are of less ancient rocks–first Millstone Grit, followed by Coal Measures. Many of the cliffs are extremely folded and crumpled, notably at Saundersfoot where the Ladies' Cave upfold (anticline) is a famous feature.

All the offshore islands are a continuation of the nearest mainland rocks. Off St David's there are Ramsey, the Bishops and the Clerks, which are mainly an extension of the Ordovician volcanic and sedimentary rocks of the Park's north coast. At the southern end of St Bride's Bay, Skomer is an outcrop of the Silurian volcanic rocks of Wooltack Point. Miles out into the sea lie Grassholm, the Hats, the Barrels and the Smalls–the most westerly fragments of Wales. They too poke up from underwater reefs of these Silurian volcanics. Skomer's close neighbour, to the south, is Skokholm whose pink cliffs proclaim that they are made of Old Red Sandstone. So do

Right: The Park has a numerous and varied insect population, best-known among which are the butterflies and dragonflies. The flowery slopes above the sea are where the butterflies can be seen at their best. Among the residents are the large skipper, the small skipper (shown here on a clover head), the meadow brown, the gatekeeper, the grayling, the comma, the common blue and three fritillaries–the marsh, small pearl-bordered and dark green. Migrant red admirals and painted ladies are abundant in some years.

Below: A chough preening. This handsome but rare bird can be seen in the Park.



those of Gateholm, a half-tide island near Marloes. Off Tenby in the far south, Caldey Island is half limestone, half sandstone.

Pembrokeshire plants One of the glories of this Park are the spring flowers which line the waysides, especially along the banks of the southern lanes wherever the soil is lime-rich. There are long stretches white with scurvy-grass or, in damper places, sheets of ramsons. Mingled with them are pink masses of campion and the pure blue of germander speedwell. Two tall umbellifers, cow parsley and alexanders, grow there with special luxuriance amid a profusion of extra-large hart's-tongues and soft shieldferns. Along south-eastern lanes in April you may come upon the Tenby daffodil, a plant of mystery because botanists are uncertain whether it is a product of gardens or is a genuine wild plant peculiar to this part of Wales.

Woodlands in this part of Wales are few and most are tucked away out of the prevailing south-west winds. They lie mainly along the sheltered Gwaun Valley near Fishguard and the equally quiet upper reaches of the East and West Cleddau rivers at the head of Milford Haven. There are also woods alongside the lily ponds at Bosherston; and close to the sea are woods at Goultrop, at the south end of St Bride's Bay and near Saundersfoot. They all have a wealth of wild flowers, especially those at Bosherston, where ash trees, wood spurge, early purple orchids, black bryony and traveller's-joy all speak of a limestone soil. Up on the northern slopes of the Preseli Hills, near the famous chambered tomb of Pentre Ifan, is a very different kind of wood. Growing on acid rocky ground in a high rainfall area this ancient wood is known for the many lichens, mosses, liverworts and ferns flourishing in its deep, moist gullies.

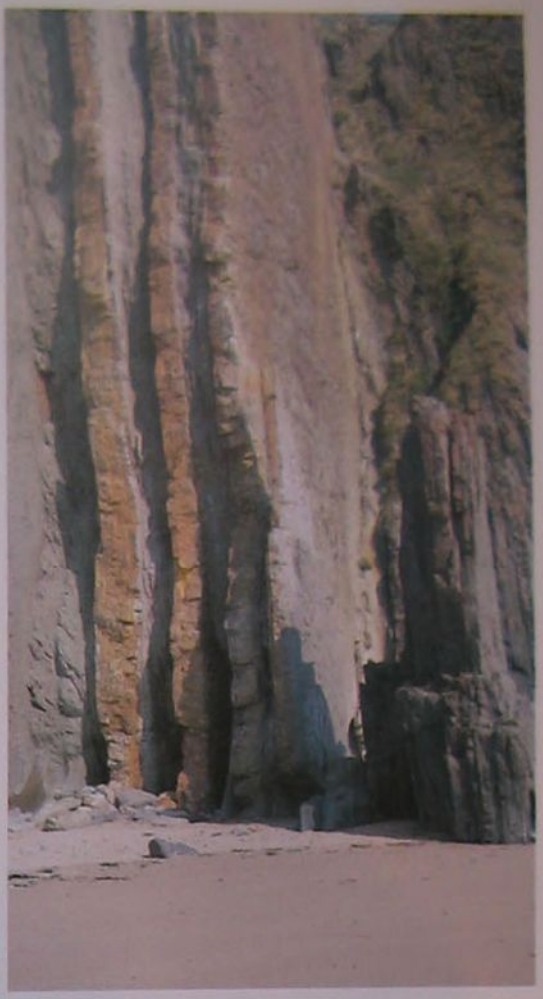
Scattered along the north from the Preseli Hills to St David's are peat bogs large and small, some of them under the threat of drainage. They are home for many plants of acid wetlands–bogbean, bog asphodel, marsh St John's wort and various orchids and sedges. Among rarer species there are pillwort, wavy St John's wort, oblong-leaved sundew, bog orchids, marsh clubmoss and, uniquely in Wales, pale butterwort.

Sand dunes and saltmarshes add their specialities to the floral variety of the Park. On the dunes you'll find sea holly, burnet rose, sea bindweed and various orchids; and on the saltmarshes lax-flowered sea-lavender, a rarity elsewhere in Wales, spreads sheets of purple-blue. However, the outstandingly

Above: A view of Skokholm's cliffs; part of Skomer can be seen in the distance.

Right: A bedstraw hawkmoth –a speciality of the Park.

Below: Otters still frequent Pembrokeshire's streams.

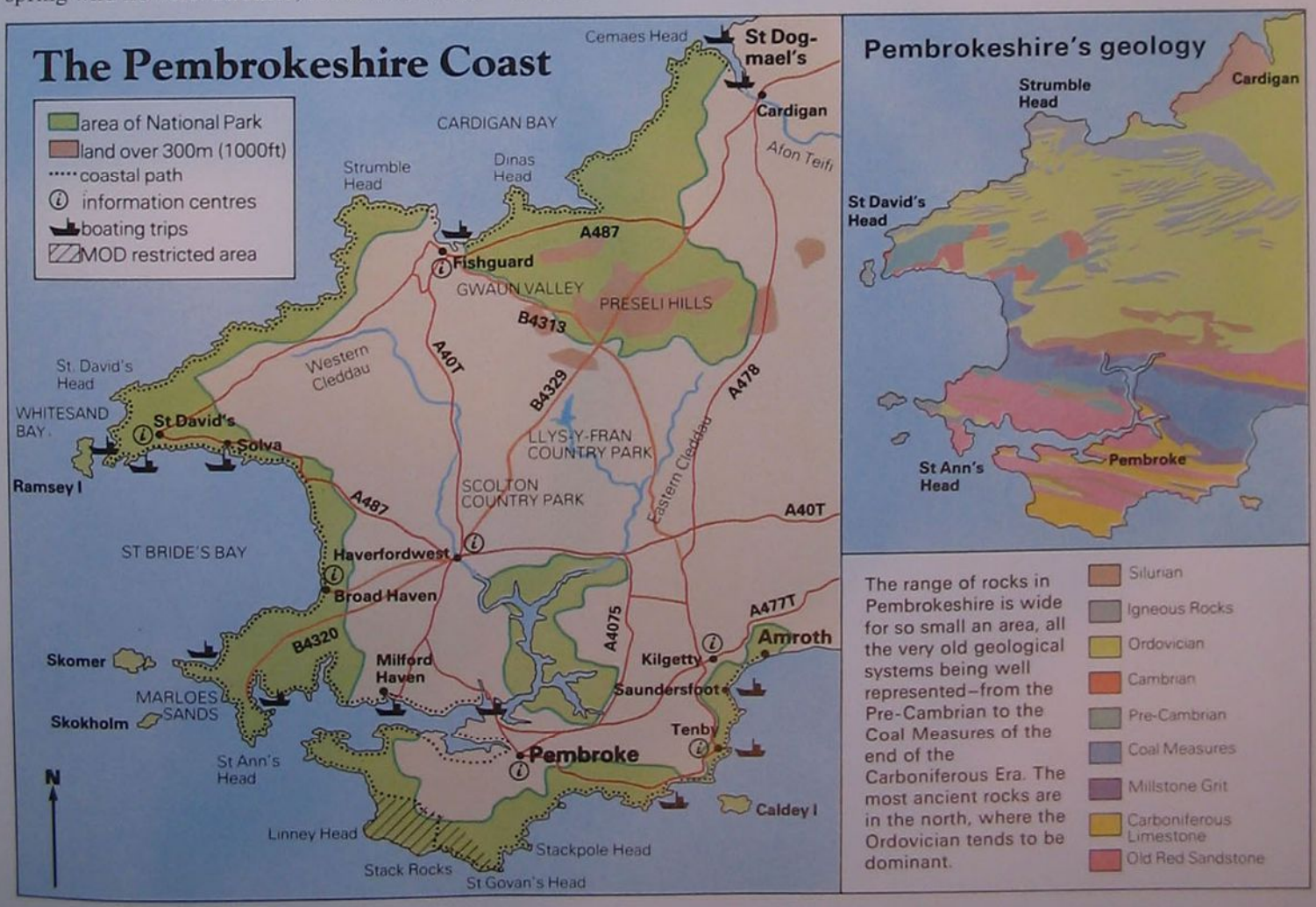


beautiful wild habitats are the cliffs and slopes immediately above the sea where, in spring, you can find endless natural rock gardens colourful with the pink of thrift, the blue of squill and sheep's-bit, the yellow of gorse, kidney vetch, bird's-foot trefoil and cowslips, along with white patches of sea campion, scurvy-grass and ox-eye daisies. Summer brings the flowers of rock samphire, golden samphire and saw-wort. Among the rarer plants of the cliffs are yellow cicendia, hairy bird's-foot trefoil, spiked speedwell, hairy greenweed, perennial centaury and two kinds of rock sea-lavender.

The offshore islands, too, are a delight of spring wild flowers: Skomer, for instance, has

Above: A magnificent emperor dragonfly. Such dragonflies are widespread in the Park, but their favourite haunts are the boglands of the north and west and the lily ponds at Bosherton in the south.

Right: The very varied geology of Pembrokeshire is often impressive–as witnessed by these vertical rock strata, which can be seen on the coast near Marloes.



great sheets of bluebells and thrift, and red campion flourishes in abundance in a soil made nitrogen-rich by seabird droppings.

Mammal variety The most noteworthy wild mammals of this Park–and certainly the easiest to observe–are the grey seals. You will find most of them along the north and west coasts and very often all you see of them is their round heads sticking out of the water as they watch you with big-eyed curiosity. They breed in autumn, mainly on the islands of Ramsey (about 200 pups a year) and Skomer (about 60 pups).

There is no shortage of foxes or badgers in Pembrokeshire. Foxes are found at all altitudes and badgers flourish in the lowlands, especially in woodlands and in the narrow little valleys going down to the shore. There are also ancient badger setts on the wild slopes near the sea cliffs, either hidden in bracken or wide open to the sky. They form deep, safe, roomy refuges not only for the badgers but also for stoats, weasels, polecats and rabbits. The ever-declining otter is still present along the streams but in its old haunts these days you are more likely to see American minks which, having escaped from fur farms, are now well-established in south-west Wales.

Hares are so few that they have even been introduced in a few localities, but rabbits more than make up for the scarcity of hares. Until myxomatosis decimated them in 1954-5, they were extremely abundant and trapping them for their meat was one of the local industries. Today they are again common in many places, but to see them in their former multitudes you need to visit such islands as Ramsey or Skokholm.

The red squirrel, one common in the woods, has now been almost entirely replaced by the grey. Of the smallest mammals, six are widespread: common, pygmy and water shrews and bank, field and water voles. The harvest mouse and dormouse are probably only very local. Bats found in the Park include the greater and the lesser horseshoes.

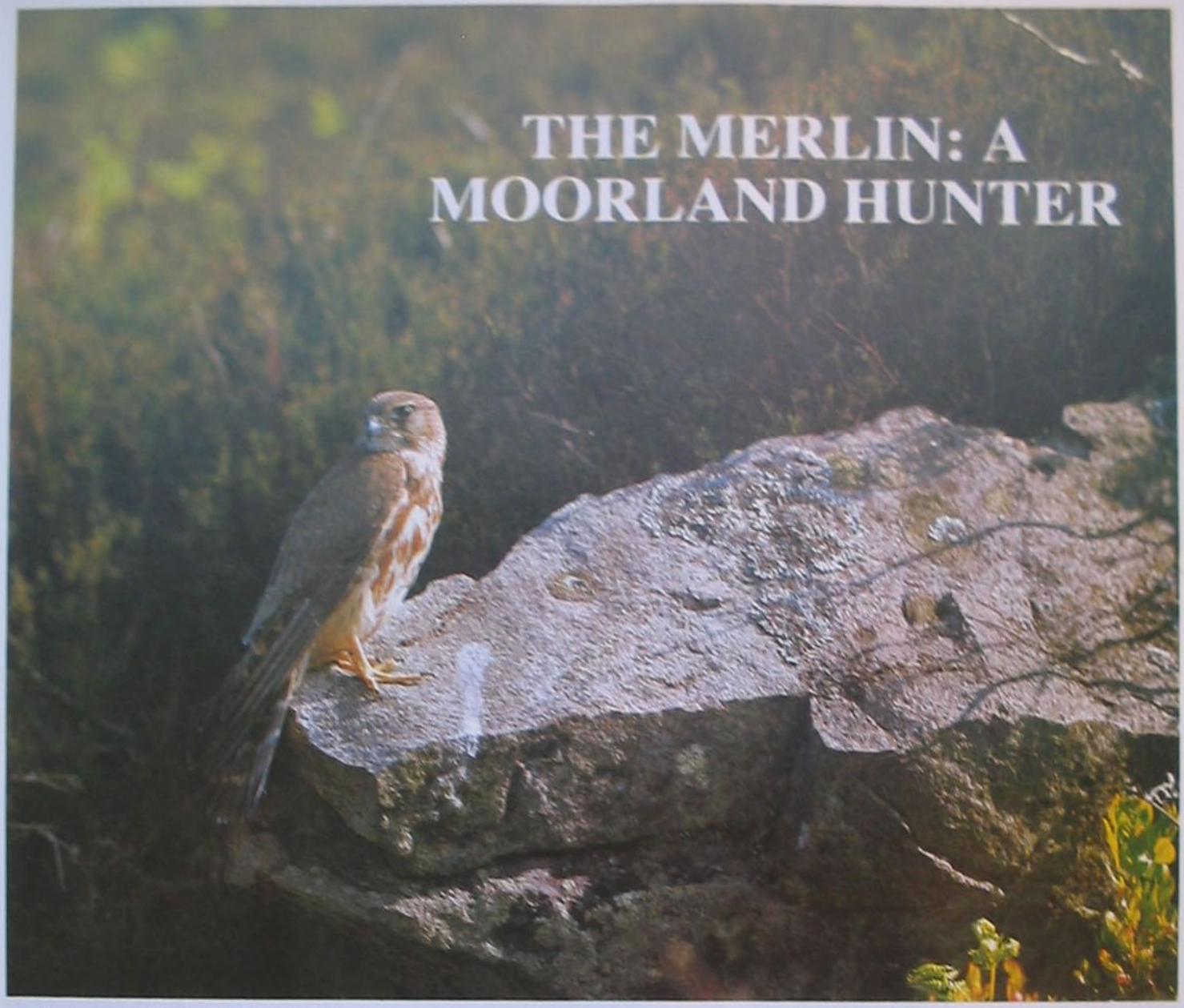
Above: Kittiwake and chick on their cliff nest–the island of Skomer has large numbers of these seabirds.

Below: The lovely burnet rose flourishes on the sand dunes in the Park.

Seabird watching Birdwatchers come to the Park mainly to visit the cliffs and islands. Peregrines, ravens, buzzards and choughs can be seen anywhere, and there are fine congregations of breeding seabirds. Breezy Stackpole Head is one of the best mainland colonies, but an easier one to see (because you can take your car in close) is the great throng of guillemots, razorbills and kittiwakes on the twin Stack Rocks–two massive sea-girt limestone pillars just off the cliffs four miles west of Stackpole Head. (The Stack Rock are usually visited on bank holidays or weekends, when the nearby military firing range is not in use. Please take great care to observe the notices that give details of when the firing ranges are being used.)

The best of the bird islands, from north to south are: Ramsey, which has small seabird stations but is most distinguished for its 10 or 12 pairs of choughs: Skomer, with huge numbers of shearwaters, kittiwakes, puffins, guillemots, razorbills and gulls; and Skokholm, which is famous not only for seabirds, including 6000 pairs of storm petrels, but also for its migrant land birds. Finally, far out to sea, is Grassholm, which has one of Britain's biggest gannetries at over 20,000 pairs.

THE MERLIN: A MOORLAND HUNTER



Above: A female merlin perched on her lookout rock. The merlin is the classic low-level hunter of open moorland, pursuing its prey just a few feet above the heather. The bulk of its food is taken from ground-nesting species, most of which are small birds weighing less than 50g (2oz), although ring ouzel, mistle thrush and fieldfare–all considerably heavier birds weighing up to 140gm (5oz)–are also taken. Because of her larger size, the female merlin is better able to capture these big items of prey.

Our smallest British falcon, the merlin inhabits the lonely moorlands of the north and west, where it is noted for its speedy, agile flight and fearless character.

Where larger birds of prey such as buzzards, peregrines and kestrels search for prey in a high, soaring flight, the merlin lives and hunts in the lowest band of air space just a few feet above the ground. The male merlin is no bigger than a mistle thrush and has slate-grey back and wings, each individual feather having a black shaft giving the overall plumage a finely patterned appearance. The underparts are dirty white with strong rufous or brown markings and the tail is slate-blue, broadly banded and tipped with black.

As with other birds of prey the female, at about 210g (7½oz), is markedly larger and heavier than the male. Her plumage is more uniformly brown and she may justifiably be confused with a female kestrel. Both sexes of merlin have strong, yellow legs and feet, which are disproportionately large for the size of the birds.

Moorland hunter Merlins are northern birds, inhabitants of the zones in latitudes and altitudes lying beyond the tree line. They occur throughout Eurasia and North Amer-

Left: The remains of a meadow pipit–a merlin kill. During the breeding season the male plucks the prey and presents it to the female.

birds each day. The reason it has to eat so much is that it expends a great deal of energy in hunting: its striking rate is not particularly good, only 5-15% of attempts resulting in a successful kill.

Although merlins prey mainly on birds, they do not spurn smaller animals and, when summer brings a bounty to their moorland breeding areas, they profit from the large numbers of day-flying moths such as the oak eggar, fox and emperor, as well as dragonflies and other large winged insects.

Unusual associations On the open hills, the merlin has a very strong affinity with heather, an association which, although well marked, is poorly understood. Heather gives good cover for nesting and contains ample supplies of meadow pipits, yet moorlands without heather often hold considerably greater numbers of pipits and other suitable prey birds, but they consistently remain unused by merlins.

Another unusual association is that between certain nesting pairs of merlins and neighbouring pairs of hen harriers. Why some merlins should choose to nest so close to hen harriers is not clearly understood. However, it is possible that the small merlin derives some protection from this association. Certainly,

ica; indeed, their most southerly European breeding grounds are the British Isles, where the species is therefore at the very limit of its breeding range.

Skylarks, meadow pipits, ring ouzels and whinchats are frequently preyed upon by the merlin. All are birds that share the same open, hilly moorland, a habitat in which bird populations, both in terms of species (with the possible exception of meadow pipits and skylarks) and numbers, are low and food supplies therefore scarce. Consequently, the merlin – in common with other moorland predators – is forced to rely on large and wide-ranging territories.

For such a small bird, the merlin eats an impressive amount of food, a single individual being known to kill and eat more than two

Tracking techniques

To discover how serious is the merlin's decline, the RSPB in Wales is using a technique called radio telemetry in which a minute radio transmitter is attached to two of the tail feathers of adult birds. This allows the RSPB to monitor the movements of the birds as they hunt in the surrounding countryside. By this experiment the RSPB hopes to learn exactly what percentages of different habitats a merlin needs in the vicinity of its nesting site in order to sustain a viable population.

Above right: A male incubating the eggs, a task done mostly by the female while her partner hunts prey for her and later their brood.

Right: Three merlin chicks, one at 18 days old and two at 17 days. In a few days' time they will begin to tear up their own food, instead of having it done for them, and the female will then be able to join her mate in hunting.

Left: The same chicks eight days later. Soon they will take to the wing.

Above: The distribution of merlins in Britain and Ireland in the early 1970s. During the last decade its numbers have declined alarmingly: it is now virtually unknown as a breeding bird on Dartmoor or Exmoor, or in the Peak District.

Opposite left: Its large powerful feet are a merlin's principal weapons of attack.

the merlin–fast and bold though it may be–is no match for larger birds of prey and it is known to be attacked by peregrines and probably also goshawks when they come up from the lowlands to hunt the open moors for grouse and waders. Nesting in the shadow of a large and aggressive harrier (which does not attack merlins) gives the smaller predator a degree of protection that it would lack in a solitary site. It is also likely that merlins prey on small birds flushed out by the flying activities of the harrier, though this does not explain why they should choose to nest near by.

The breeding season Merlins return from their wintering grounds to the hills for breeding by April, often using the same sites year after year. Display flights take place on warm sunny days with both the cock and the hen birds participating, though these are mostly inconspicuous affairs; unlike other birds of prey merlins do not have a notable display.

In most of their British sites, merlins nest on the ground among heather, and sometimes bracken. Towards the southern end of their British range, however, the majority of pairs make use of old nests of crows or magpies in isolated hawthorn or rowan trees.

Merlin (*Falco columbarius*). Resident bird of prey; Britain's smallest raptor, length 27-33cm (10½-13in), the female being noticeably bigger. Wingspan 52-69cm (20½-27in).

Merlins breed late, not laying until well into May in most areas, so that the young hatch at a time when there is a surplus of newly fledged (and therefore easily caught) young birds of other species. The four or five beautiful red-brown eggs–beguilingly tempting to generations of egg collectors–are laid at intervals of two days and hatched mainly by the female. The female alone tends the young and feeds them with items provided by the male. It is a time of great activity for him, for he has to bring in four or five kills a day, ready plucked for the female to feed to the chicks.

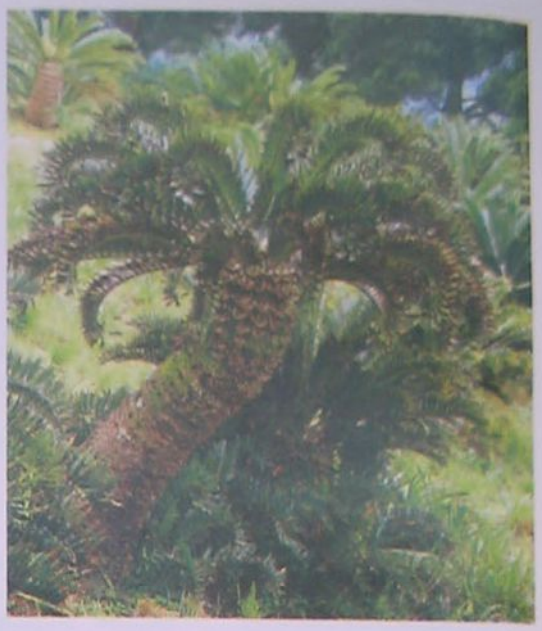
Four weeks after hatching the young are taking to the wing. They become independent a month after fledging, but family groups may well keep together for a while longer.

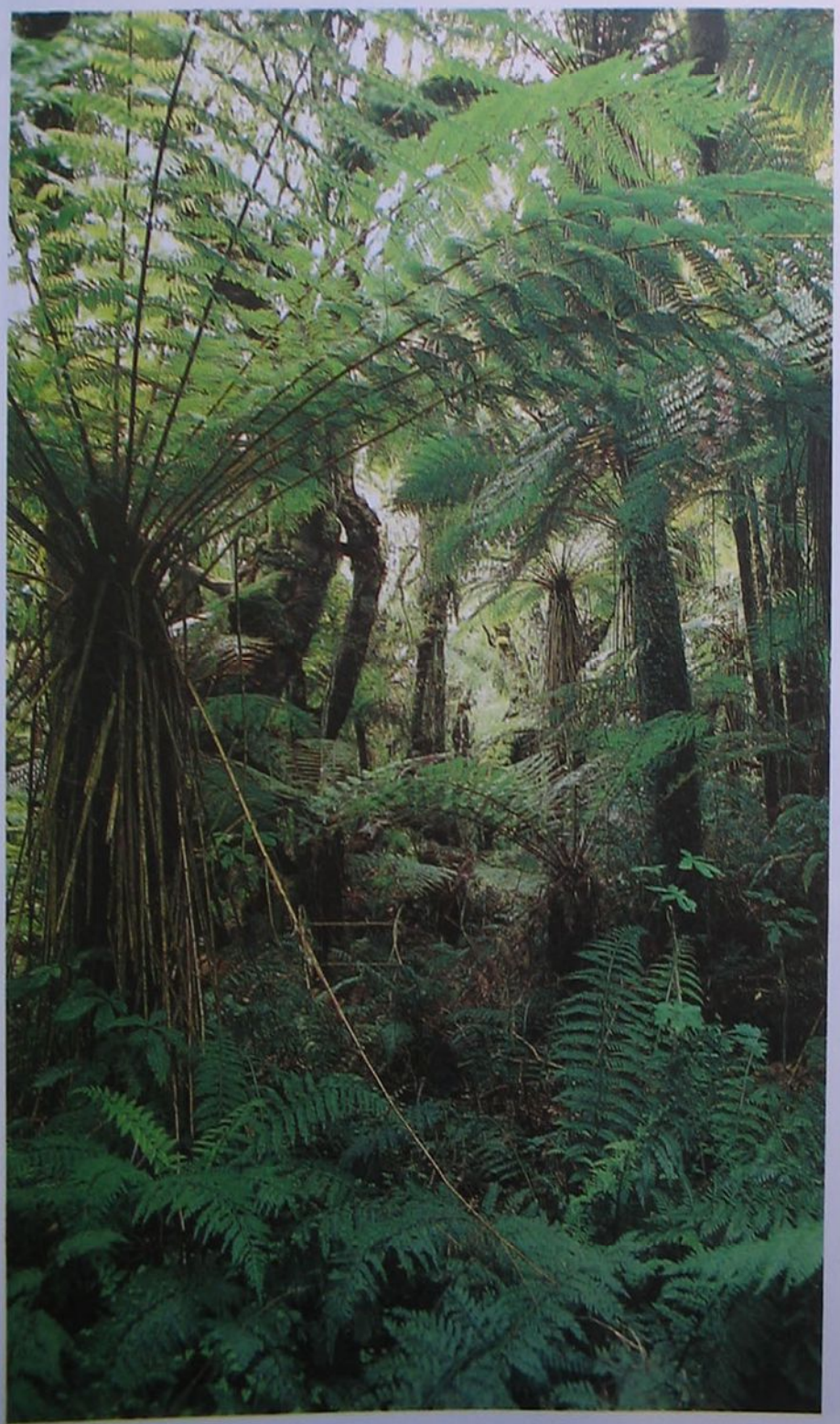
In autumn and winter some merlins hunt in the farmlands surrounding their moorland breeding sites, though they are most at home at this time of year on the marshes of our major estuaries. The majority of British estuaries have several merlins resident throughout the winter, some of which are Icelandic birds wintering here. British birds do not move much more than about 100km (60 miles) from their birth place, though young merlins regularly travel as far as western France during their first winter after fledging.

The merlin is now a scarce British bird but in days when it was more numerous, for example in the first half of this century, it bred quite commonly in areas away from its traditional open hills. Pairs used to breed regularly in sand dunes and on undulating heathery headlands on western clifftops. Since then the merlin's fortunes have been mixed.

PLANTS IN BRITAIN THROUGH THE AGES

Over millions of years the British flora has ranged from plants of the frozen tundra to those such as palm trees now found in tropical mangrove swamps. At one stage there were even giant club-mosses and horsetails the size of modern trees.





The modern British landscape is almost entirely the creation of man since he first began to clear the forests to build settlements and cultivate the land. Our fossil record shows that this process first occurred about 5000 years ago. But what was Britain's plant cover like before man began his activities?

One major method of investigation is to look at fossilised pollen grains in the rocks – pollen shed from plants perhaps hundreds of thousands of years ago, and which accumulated in peat bogs and lake sediments. This pollen may be recovered and compared with pollen from living plants to identify which plants used to live in a particular area.

The Ice Ages The pollen record shows that over the last half million years Britain has been affected by a succession of ice sheets advancing south and then retreating north – the Ice Ages. At its maximum extent the ice reached as far south as north London and the most recent Ice Age was at its height about 20,000 years ago. During these glacial periods (as the Ice Ages are sometimes known) the average yearly temperature was −6°C (21°F) or even lower. In those parts of Britain that escaped the ice, pollen analysis shows that the vegetation was similar to that found in modern-day areas of tundra or steppe, such as that of northern Scandinavia. It consisted mostly of herbaceous plants – grasses, sedges and mugwort – with a few small shrubs such as juniper, dwarf birch and willow.

Between the Ice Ages the weather gradually became warmer and the vegetation changed. First, birch and coniferous trees, mainly pine, moved in. Then, as conditions became warmer still, they were replaced by broad-leaved forest, predominantly oak, elm, alder and hazel, with hornbeam and fir establishing themselves later on. As the weather deteriorated with the onset of the next Ice Age the coniferous forest, and then tundra, returned.

The last Ice Age ended about 10,000 years ago, and when man first began to clear the land for his own purposes Britain was almost

Left: A modern cycad, the descendant of a group of primitive non-flowering plants that, between 100 and 200 million years ago, formed a major part of the British vegetation. Today, however, they have dwindled to just 100 species confined to the tropics.

Far left: This picture gives an idea of how Britain might have looked 300 million years ago during the Carboniferous period, when parts of our landscape were dominated by tree ferns, a group of plants that continued to survive in Britain until about 50 million years ago.

wholly covered with broad-leaved woodland. There were, however, areas of coniferous forest in the cooler northern parts of Scotland. Remnants of this still exist today in the form of the Caledonian Forest.

Back to the Tertiary If we go back to millions of years before the Ice Ages we find that Britain's vegetation was quite different. During the early part of the geological period known as the Tertiary, about 45 million years ago, Britain was covered with luxuriant forests of large trees festooned with climbing plants. It would have looked similar to the tropical regions of south-east Asia today.

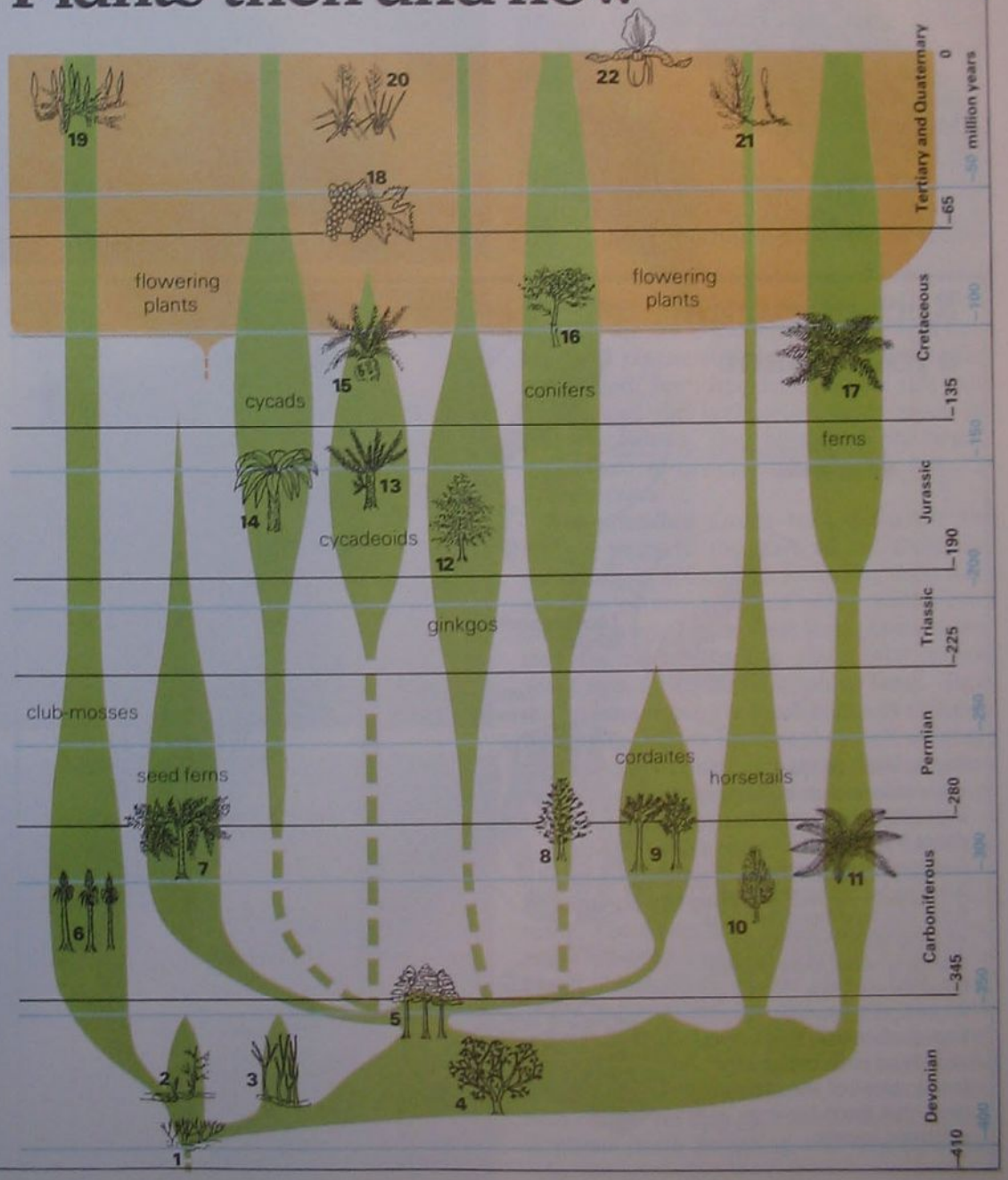
The vegetation of this period is investigated mainly by looking at fossilised fruits, seeds, leaves and wood. It turns out that many of the plants growing here at that time are closely related to modern garden and ornamental plants such as magnolias, grape vines, palms and gourds, and members of the walnut and laurel families. All these once grew naturally in southern England and, whereas today some can still grow outdoors in Britain, many other members of this ancient vegetation can only grow today in tropical regions. For example, the coast of Britain during the early Tertiary consisted of a mangrove swamp dominated by stemless *Nipa* palms and similar to the swamps of modern Malaysia.

During the later stages of the Tertiary the temperature began to decline as the first of the Ice Ages approached. The coastal mangrove swamp was replaced by freshwater marsh similar to the modern Florida Everglades and, inland, the vegetation became less tropical as species began to disappear. Around this time, about 20-25 million years ago, grasslands and their associated grazing animals first began to dominate large areas of the world. Before that

Plants then and now

The major plant groups, showing their relation with one another, and typical species. The width of each group indicates its importance at that time. Dotted lines show possible connections. Note the dominance of flowering plants since the Cretaceous.

1 *Cooksonia* (primitive).
2 *Asteroxylon* (primitive).
3 *Rhynia* (primitive).
4 *Psilophyton dawsonii* (primitive).
5 *Archeopteris* (progymnosperm).
6 *Sigillaria* (arborescent club-moss).
7 *Medullosa* (seed fern).
8 Early conifer.
9 *Dorycordaites* (cordaite).
10 *Calamites* (arborescent horsetail).
11 *Zeilleria* (early fern).
12 Maidenhair tree (ginkgo).
13 *Cycadeoidea* (cycadeoid).
14 *Paleocycas* (cycad).
15 *Williamsonia* (cycadeoid).
16 Pine (modern conifer).
17 *Dryopteris* (modern fern).
18 Grape vine (flowering plant).
19 *Lycopodium* (modern club-moss).
20 Meadow-grass (flowering plant).
21 *Equisetum* (modern horsetail).
22 Orchid (flowering plant).



time, grassland was not a feature of the earth's vegetation–hard though it is to imagine.

A world without flowers A world without grassland seems strange, yet it is even harder to imagine one without any flowering plants. However, we must try to do this because, although the flowering plants are the most dominant group of plants in the world today, they first occurred only 120 million years ago, during the Cretaceous period. Before the flowering plants developed the vegetation of Britain, and of the rest of the world, was dominated by the gymnosperms–a group that includes conifers, cycads and maidenhair trees.

Today, cycads are a small group of plants growing in the tropics and looking rather like stunted palm trees. However, the fossil record shows that this group of unattractive plants once formed a major part of Britain's vegetation and was represented by many species. A group of related plants, now totally extinct, called cycadeoids was also widespread at around the same time–between 225 and 125 million years ago. Fossil remains (mainly leaves, stems and isolated cones) may be found in the Jurassic rocks of Dorset and the Weald of southern England.

Maidenhairs reached their zenith about 190-140 million years ago. Their fossil remains are very common in the Jurassic rocks of Yorkshire. Today, however, only a single species of this once-important group is left.

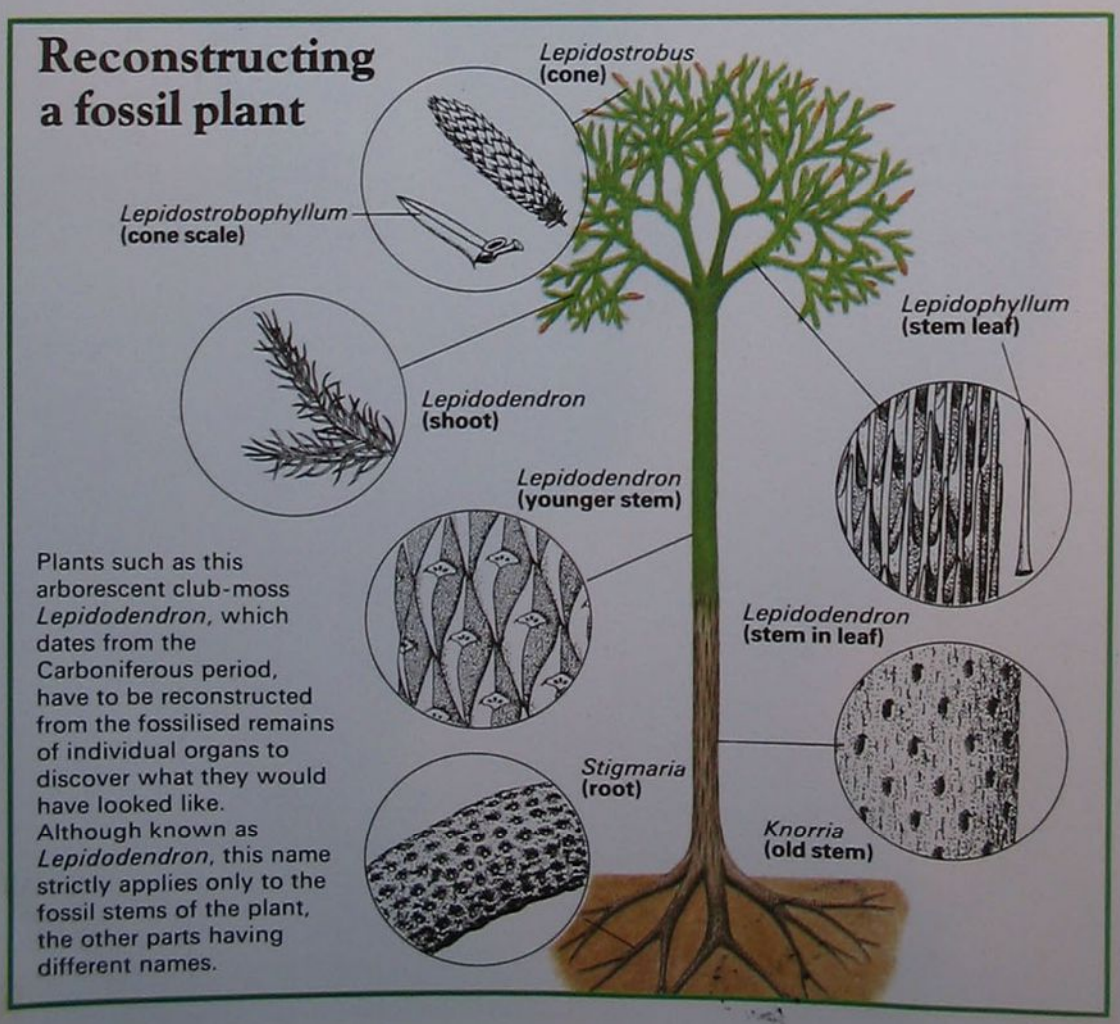
This is *Ginkgo biloba*, a tree that still grows wild in the forests of China and is widely grown in Britain as an ornamental.

Growing alongside these cycads, cycadeoids and maidenhairs were extinct relatives of the modern pines, cypresses and redwoods. The earliest conifers looked similar to a Norfolk Island pine, a modern tree belonging to the same genus as the monkey puzzle tree. Fossil remains of these early conifers have been found in the Coal Measures of Yorkshire, which were laid down during the Carboniferous period around 300 million years ago.

During the Carboniferous period the most important group of seed plants (as distinct from spore-bearing plants) were a now-extinct group called seed ferns because they had fern-like foliage. Some looked like modern tree

Above left: A fossilised horsetail compared with a modern species, the wood horsetail (*Equisetum sylvaticum*), shown above. Both show the same whorling pattern, though in the fossilised species the structures radiating from the central stem are leaves while on the modern plant they are branches–the leaves instead closely clasping the stem.

Reconstructing a fossil plant



Plants such as this arborescent club-moss *Lepidodendron*, which dates from the Carboniferous period, have to be reconstructed from the fossilised remains of individual organs to discover what they would have looked like. Although known as *Lepidodendron*, this name strictly applies only to the fossil stems of the plant, the other parts having different names.

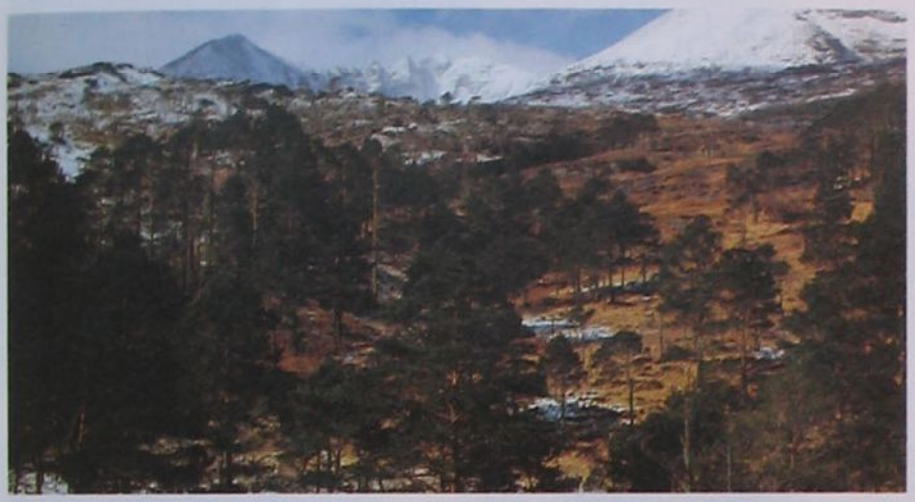
Right: A sequence of landscapes showing how Britain might have looked during the last Ice Age and the changes that have occurred since.

Tundra During the last Ice Age areas not actually covered with ice had a vegetation similar to that of modern tundra: mostly herbaceous plants such as grasses and sedges with a few low-growing shrubs such as dwarf birch and willow, and juniper. Shown here is the Norwegian tundra.

Coniferous forest As the weather became warmer and the ice retreated coniferous forest, mostly of pine, and birches moved in. The Caledonian forest, shown here, is a relict of this ancient woodland that once covered most of Britain.

Broad-leaved forest As conditions continued to improve broad-leaved trees such as oak, elm and alder began to replace conifers.

Farmland 5000 years ago man began to clear the forests to produce the arable land and grassland that now covers most of Britain.



ferns, while others were herbaceous or climbing types. Flowering plants may have arisen from within a group of seed ferns, but this is not known for certain.

Also present during the Carboniferous period were a group of seed plants known as cordaites. They formed an important part of the vegetation at the time but they became extinct by the early Triassic, about 220 million years ago.

Giant club-mosses The most remarkable fossils found in Coal Measures are those of arborescent (tree-sized) club-mosses and horsetails, ancient relatives of our own modern herbaceous forms. The arborescent club mosses must have been by far the more impressive of the two groups, sometimes growing to a height of 45m (150ft) during their heyday 300 million years ago.

The two most common arborescent club-mosses were *Lepidodendron* and *Sigillaria*. Both had long straight stems covered with structures called leaf cushions. Each leaf cushion bore a scar where a thin needle-shaped leaf was attached when the tree was younger. On *Lepidodendron* the leaf cushions were diamond-shaped and arranged spirally around the trunk. On *Sigillaria* the leaf cushions were more or less square and arranged vertically up the trunk. The former tree had an extensive system of branches at the top of the trunk while the latter branched only once or twice.

Also present during this period were small herbaceous club-mosses and horsetails, looking very similar to modern species. Ferns were also well represented during the Carboniferous period, both tree ferns (which still exist today) and the herbaceous types more familiar in Britain. They have remained largely unchanged in appearance over the last 350 million years.

The primitives Going back a further 100 million years to the start of the Devonian period about 400 million years ago, there were no trees of any sort and many plants even lacked leaves. The earliest land plants colonized the earth's surface about 410 million years ago. (This is discounting fungi, algae and mosses which are fundamentally different from other plants because they lack an outer protective covering–the cuticle–with stomata for exchanging gases and a vascular system for conducting water through the plant.)

These primitive early land plants consisted of upright forking green stems growing from a rhizome on the ground, but they lacked true roots. The stems bore spore-producing sporangia on their tips and grew to a height of about 20cm (8in). Some plants had small spiny outgrowths on the stems–the first simple leaf-like organs. Others had rather more complicated branching systems. All these primitive plants have, of course, long been extinct yet they gave rise to the vast range of plants–both flowering and non-flowering –that we see today.

Above: Free-range Roman geese. Geese are uncommercial, free range birds of little interest to the poultry specialist. They are bred solely for their meat, although a goose egg makes a fine meal.

THE CHANGING FACE OF POULTRY FARMING

In recent decades British farming has undergone an economic revolution. The high cost of labour and land has encouraged intensive, specialised systems based on heavy capital investment. Nowhere is this more apparent than in poultry farming, but free-range and semi-intensive systems remain.

When labour and land were cheap, and markets insecure, it was sensible for farmers to diversify, converting the by-products of their main enterprise of dairying or cereal production into marketable commodities, such as poultry and eggs. This provided economic security and a degree of self-sufficiency. Even when the sideline became the major source of income, it was within the familiar, reassuring context of field and farmstead.

Now, however, it is different. The emphasis is on cash crops sold into artificially stabilised markets to pay off the overdraft, the fuel bill, the chemical company and the accountant. The sidelines have become specialised industries in their own right and their former association with the land has been severed. In

Below: A Bantam leading Old English Game chicks across the grass. Bantams are miniature versions of standard poultry breeds, although some of them are relatively large.

no branch of farming has this transformation been greater than in the poultry industry.

Free-range poultry The downfall of the free-range fowl can be traced to its diet. Chickens, ducks and turkeys, like pigs and humans, cannot digest large quantities of low-value green food such as grass, and they have a correspondingly high requirement for concentrated carbohydrates and proteins. Under natural conditions fowl satisfy this need with seeds, worms, slugs and insects, all found in abundance around the traditional farmstead.

For centuries poultry farming was something of a free-for-all: free insects and grain to be pecked out of the dunghill and the stubble by foraging hens, free eggs for the farmer, if he could discover where they had been laid, and every so often a free supper for the fox.

The tidy-minded could flush the birds from their accustomed roosts in the barn or hedge and encourage them to spend the night locked in a shed. Here they laid their eggs before release in the morning, and were protected from foxes, provided the door was secure. Slackness in this respect could be disastrous, for in the confined space the fox would kill many more birds than it could eat, even destroying the whole flock.

Fifty years ago the majority of British poultry was housed in this way, either in a permanent building in the yard or, in the case of a large chicken flock, in portable houses out in the fields. Allowed free range during the day, the chickens could obtain a large proportion of their food themselves during summer, particularly after the harvest when they foraged for spilled grain and weed seeds in stubble, pecked out leatherjackets and wireworms and generally cleaned up the field for the next crop. Used in this way, the poultry flock fulfilled a useful role in the mixed farm economy.

Above: A Muscovy duck and her ducklings. All other breeds of domestic duck are descended from the mallard, but the Muscovy is a separate race and when crossed with other ducks it has sterile offspring.

Below: Free range turkeys– a rare sight these days. Like chickens, most turkeys are kept in 'controlled environment' housing– intensive broiler units where they are fattened.

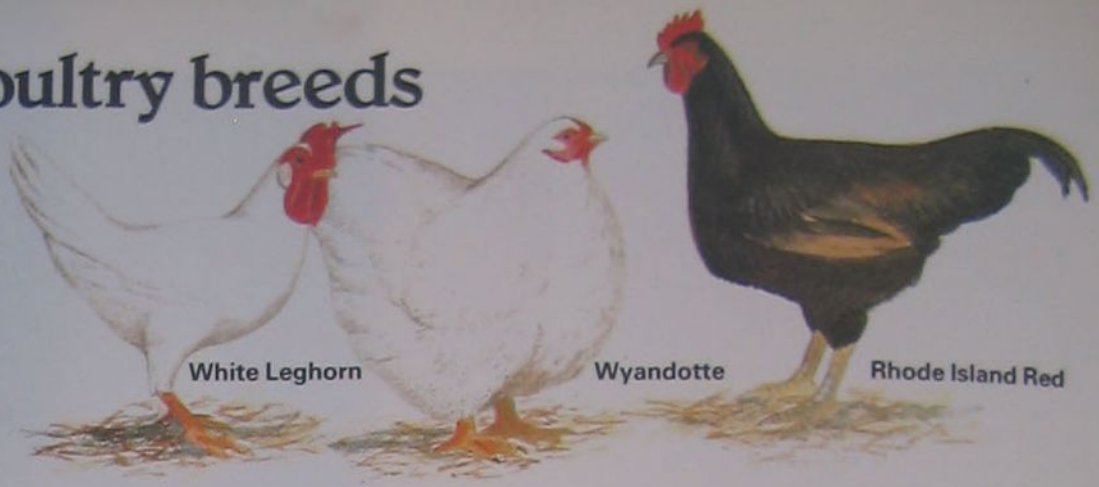
This is, in fact, the only way to keep geese on a large scale, for they differ from other poultry in having an appetite for grass. It is uneconomic to house them intensively and bring the grass to them, so they are normally kept on free range. They do best on good quality, fairly short grass, and traditionally the annual goose kill took place at Michaelmas (September 29), when the grass had stopped growing. Christmas geese have to be fed on for the intervening weeks; today this constitutes the only predictable market, so what with extra feed costs and the demand for good grazing land during summer, the goose business is much contracted.

Small-holdings By contrast, chickens, ducks and turkeys cannot eat bulky forage, so there is no direct value in allowing them access to grazing which can be more profitably used by sheep and cattle. Their food requirements may be conveniently met with a compound of cereal grain and an animal product such as fish meal, supplemented if necessary by the addition of drugs to combat the numerous diseases to which poultry are prone. Fed this way, the birds can be confined behind wire with no obvious ill-effects. Such semi-intensive housing has long been used by the smallholder, in the form of a henhouse opening into a wire-netting-enclosed run designed to keep the birds off the garden and the foxes off the birds. A larger-scale version is commonly used by commercial duck enterprises, and by other breeders.

Such a run cannot of course effectively be cleaned, and if the birds are to be kept at high density the enclosure (or the stock) must be shifted periodically to prevent a build-up of parasites and disease organisms. An alterna-

British poultry breeds

Chickens (right): There are over 50 standard breeds divided into light or laying breeds (eg Leghorn and Wyandotte), heavy table breeds (eg Indian Game) and dual-purpose breeds (eg Rhode Island Red and Light Sussex). These last two breeds are very popular with smallholders for their eggs and meat. Each battery hen may lay up to 300 eggs in the first year.



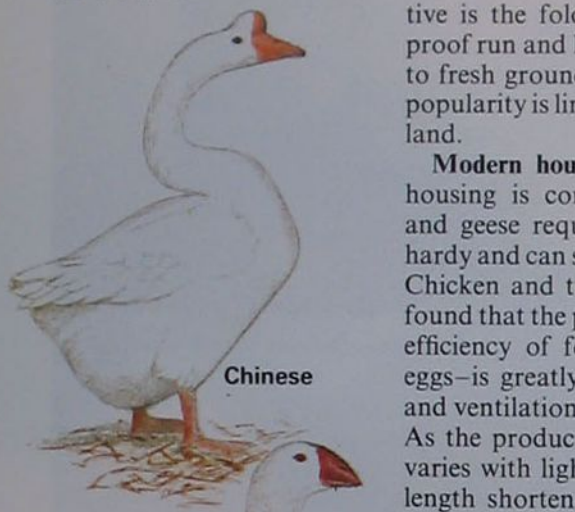
tive is the fold unit, a small, portable fox-proof run and henhouse which is moved daily to fresh ground in the open field. Its current popularity is limited by the price of labour and land.

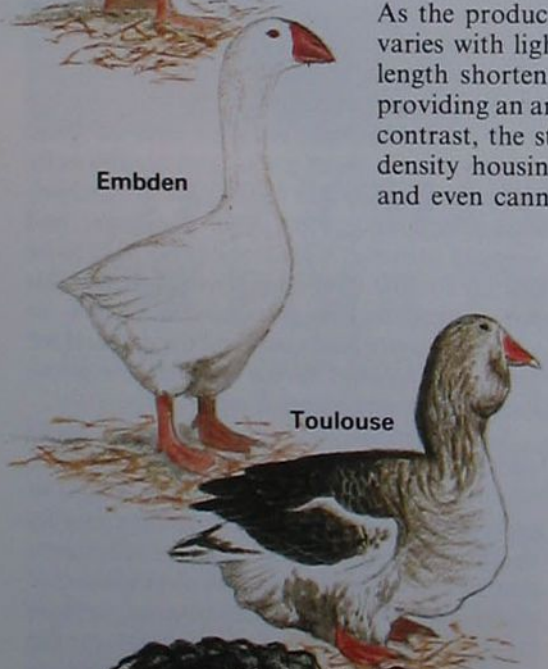
Modern housing In all these systems the housing is comparatively primitive. Ducks and geese require nothing else for they are hardy and can survive in the open if necessary. Chicken and turkey farmers, however, have found that the performance of their stock–the efficiency of food conversion into meat or eggs–is greatly improved if the temperature and ventilation are kept at a steady optimum. As the production of eggs from laying hens varies with light levels, falling off as the day length shortens, there is great advantage in providing an artificial 14-hour day all year. In contrast, the stress factor inevitable in high-density housing, which can lead to fighting and even cannibalism among uncaged birds raised for meat, can be suppressed by maintaining a low light level at all times.

These are just some of the reasons why practically all the poultry and eggs produced commercially today are derived from vast flocks kept in 'controlled environment' houses. Each long, low windowless building contains several thousand birds confined in battery cages, or jostling for space on a wire floor or deep litter (a half-metre layer of straw or wood shavings which absorb a year's output of manure). Such buildings are recognisable by the storage hoppers for the compound feed mounted at one end to supply the automated feeding systems. Certainly one will look in vain for a chicken.

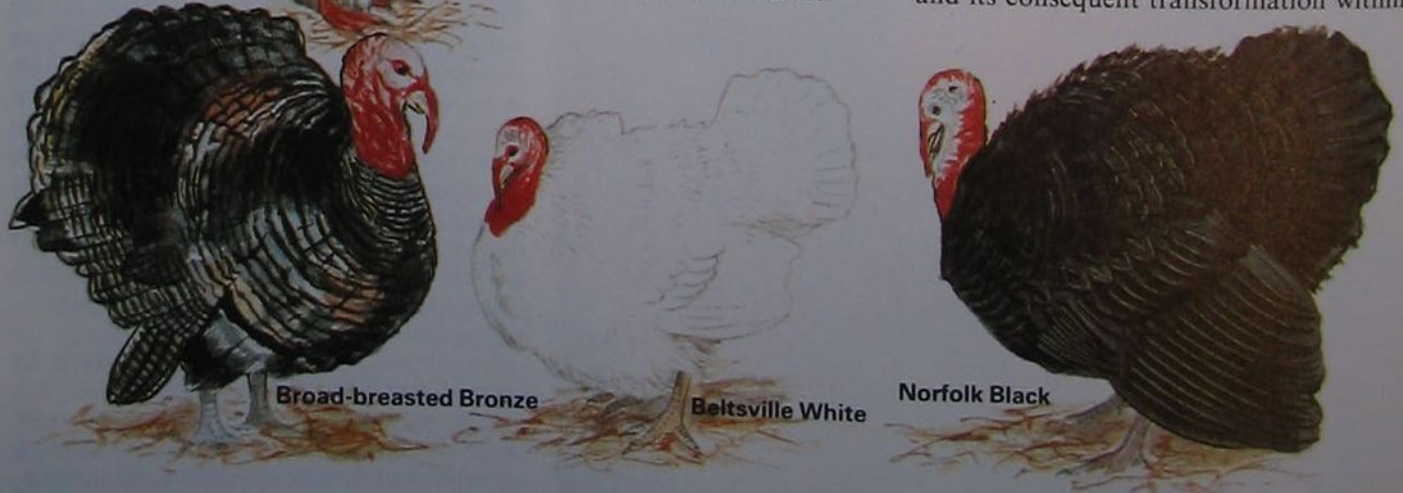
The battery cage system is designed for laying hens. The combination of 'optimum environment' and enforced inertia concentrates the hen's energy on egg production; as each egg appears it rolls forward into a collecting tray or on to a conveyor, and the hen lays again to make up the deficit. Each bird may lay over 300 eggs in the first year, before production drops off sharply in the eight-week moulting period. At this stage the bird is usually replaced as it cannot sustain such a prodigious output throughout a second year.

The majority of loose housing is occupied by broiler birds–chickens or turkeys bred to achieve rapid weight gains under ideal conditions. It is this system which is responsible for the increasing availability of poultry meat and its consequent transformation within 30





Geese (left): The goose enthusiast still relies on traditional breeds, mainly the large white Embden, the smaller Roman, the Toulouse, Chinese and Brecon Buff. Crosses are very popular, particularly the Embden-Toulouse, and there is a good deal of casual hybridisation among the farmyard flocks. Most geese today are kept for the Christmas market.



years from a luxury food into a supermarket staple.

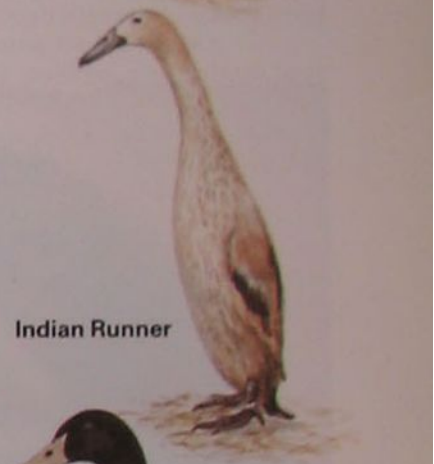
Special stock The rates of production typical of intensive poultry farms can only be achieved with specially bred stock, and there is a flourishing trade in commercial hybrids 'tailored' to intensive conditions. The birds have a short life-cycle, and within two weeks of mating two promising parent birds the breeder can assess the quality of the progeny, identify faults, and correct them by further crossing.

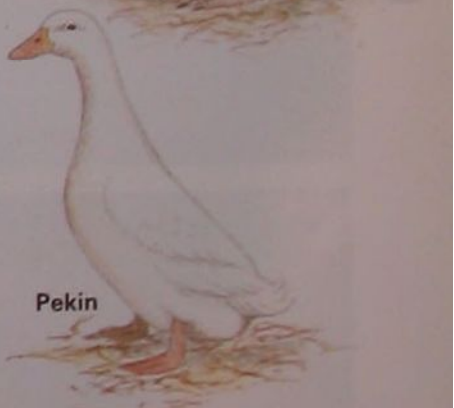
High-performance hybrids are of little use to the smallholder who expects his stock to prosper in an open-air run and an unheated henhouse on a relatively low-value diet of kitchen waste, garden produce and a minimum of bought-in concentrates. Thus most of the birds on view in the countryside are traditional breeds suited to backyard conditions.

Many breeds There are over 50 standard breeds of chicken. Many are highly decorative, owing their survival to poultry fanciers who breed them for show or simply to ornament the garden or farmyard. For practical purposes they are divided into light or laying breeds, heavy table breeds and dual-purpose breeds. These last are popular with smallholders: table birds are fed up well beyond the stage at which broiler fowl are killed, for there is a limited but steady market at the farm gate for large, well-fleshed birds, particularly if the farmer is prepared to dress and package the produce to a commercial standard.

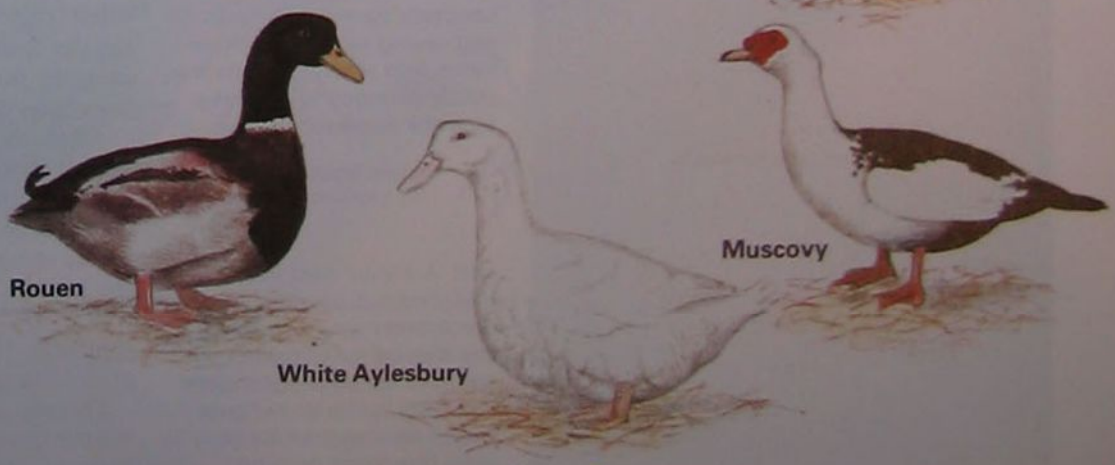
Ducks are also divided into laying and table breeds. Duck eggs are not popular, partly because of their strong flavour but also because they have a much shorter shelf-life than hens' eggs. The shell has relatively large pores and is a less effective barrier against disease. Of the table breeds, the white Aylesbury, the Pekin and the Rouen are the most popular, being well-built. Once again the market is restricted – a chicken provides more meat than the same weight of duck, and the flavour is less acceptable.

Free range and semi-intensive poultry farmers cannot compete with the big specialist producers on equal terms. Nevertheless such enterprises have survived and flourish with the help of a minority of consumers who are prepared to pay a little extra for their produce. If, in the future, domestic poultry remain a part of the living countryside, we will know who to thank.





Ducks (right): Like chickens, ducks are divided into laying and table birds, although the market for their eggs and meat is relatively small. A Khaki Campbell produces over 300 eggs a year under quite primitive conditions, matching the performance of a battery chicken, while the Indian Runner lays up to 180. The others are popular table breeds.



Turkeys (left): Like geese, turkeys are bred solely for meat. They are fattened on a large scale in intensive broiler units. As with hens, the original breeds – such as the Norfolk Black, the Beltsville and the Broad-breasted Bronze – have been superseded commercially by a constantly developing hybridisation programme. A broiler puts on 1kg of body weight for every 3kg of food consumed before it is killed at about 15 weeks.

THE RENAISSANCE OF THE HORNET

In Britain hornets are at the edge of their range and so have been rare for many years. Now, however, they appear to be making a comeback–but there is no cause for alarm, for hornets are less aggressive than their smaller cousins, the wasps.

Above: Worker hornets enlarging their nest and feeding the grubs–their younger sisters. Although the queen starts building the nest, so that she can lay her first batch of eggs, she concerns herself only with egg-laying as soon as these hatch into workers, while the newly emerged wasps take over the domestic chores.

Left: A hornet nest in a thatched hut. Hornets do not use a nest more than once, but a good nesting site may certainly be used again. One tree hole in the New Forest has been occupied for at least four years running.

Hornet–the very name strikes terror into many hearts, conjuring up visions of large, angry insects swarming around and stinging everything in sight. This is sheer exaggeration. The hornet is merely a large wasp and, although it certainly can sting, it is less aggressive than the smaller wasps, and will not usually attack unless severely provoked.

Finding a nest site Hornets are social insects with a life-style similar to that of other social wasps. Only the mated queens survive the winter, hibernating in hollow trees and similarly protected places. They usually wake in April and start to look for a nesting site. During this period they fuel themselves with sugar-rich tree sap, which is a major part of the hornet's diet. They rarely visit flowers, although queens have been known to nibble partly opened gooseberry flowers–presumably to get at the nectar.

They sometimes build their nests in roof spaces (especially under thatch), and in wall cavities, and have occasionally been found in old bee hives, but hollow trees are the most usual sites. Thus the hornet is essentially a woodland species. Ideal sites are not particularly common, and there is a good deal of competition for them; queens may actually fight over ownership, and many die in such contests.

The paper nest Having found a site the successful queen settles down to build a nest and rear her family. Building usually begins in May and each queen starts her nest unaided. Like other wasps, she builds it with paper, which she makes by scraping wood from trees and other timber and pulping it with her own saliva.

The queen hornet hangs her nest–which initially consists of a small plate of six-sided cells–from the roof of the cavity, laying an egg in each cell as she builds. The eggs begin to hatch six days after the building started.

Feeding the young Feeding the grubs then becomes the queen's major concern. The tree sap which has sustained her until now is not suitable for the grubs: they need meat, which the queen provides in the form of other insects. Caterpillars, flies, grasshoppers, and even other wasps and honey bees fall victim to the hornet, which normally pounces on them when they are resting. The queen hornet usually removes their wings and legs before carrying the victims back to the nest, where she chews them up for the grubs.

After two weeks of intensive feeding the hornet grubs are ready to pupate, and the queen can resume her nest-building activities. By the time the new adults emerge from their pupae some two weeks later, she has enlarged the nest to about 40 cells. The new adults, which are all workers, quickly set about enlarging the nest further, and feeding the grubs; the queen returns to egg-laying.

During the summer the average hornet colony rears about 950 workers, although, with an individual life-span of about four

weeks, these workers are not all present at one time. The workers collect and pulp wood, and forage for food in just the same way as the queen, and they also augment their sugar intake by lapping honeydew from the leaves.

New queens Males and new queens do not appear until well into August, the queens being reared in specially large cells which occupy most of the lower half of the nest. The extra rations brought to these cells–partly because the workers are doing little building by this time–ensure that the occupants grow into fully developed queens. Males are reared in both large and small cells, and show corresponding differences in size. The few figures available suggest that the average hornet colony rears about 290 queens and 300 males.

The males and new queens mate in late August or September, and the queens then spend one or two weeks feeding on fruit and other sweet products, accumulating considerable fat reserves to see them through the winter. Towards the end of September they seek their winter quarters. The males and remaining workers may linger on until October or November, but they then die.

Above: A hornet queen starting to build her nest.

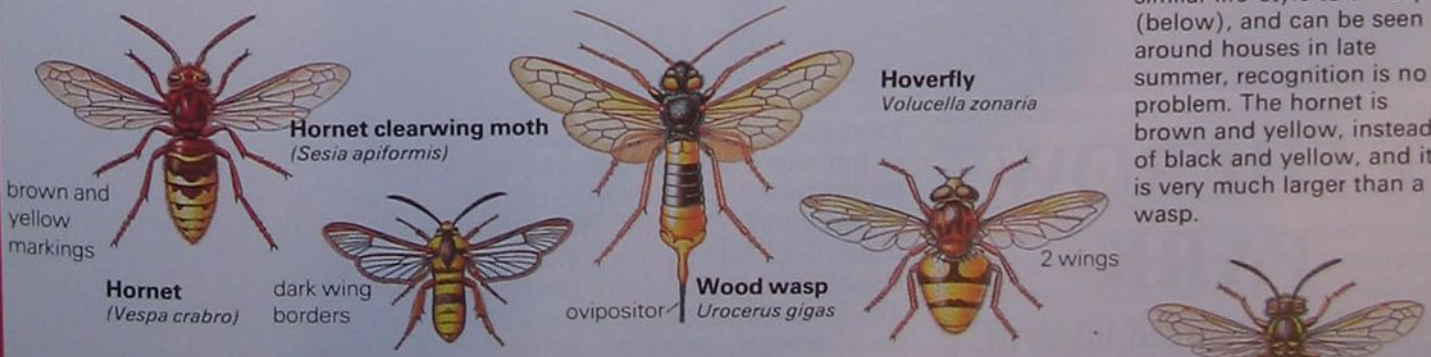
Below: Hornet pupae in their silken cocoons. They lie with their heads pointing downwards, the black marks being their eyes. The dark pupa is older than the rest and is probably about to emerge as an adult.

Fluctuating numbers The hornet is on the edge of its range in this country and, apart from a few stragglers, has always been confined to the southern counties. Its strongholds have been in a band stretching from the south-west through the West Midlands to East Anglia.

Numbers have always fluctuated, but during the first half of the century the hornet was fairly common throughout its range. The population then crashed in the 1950s and shrank back until it was almost entirely confined to the New Forest and a few places in East Anglia. Destruction of suitable breeding sites, mainly through improved forestry, may have been one cause for the decline.

In recent years, however, populations have increased in several areas and the East Anglian population has shown a marked upsurge. The hornet is now found throughout Suffolk and is spreading westwards on a narrow front through Cambridgeshire and into the East Midlands. No explanation can yet be given for this dramatic increase, but one possibility must be that the Suffolk hornets are now able to utilise a wider variety of nest sites than their tree-orientated ancestors.

Hornet mimics



Although hornets have a similar life-style to a wasp (below), and can be seen around houses in late summer, recognition is no problem. The hornet is brown and yellow, instead of black and yellow, and it is very much larger than a wasp.

Several insects mimic the hornet's warning coloration to gain protection. The hornet clearwing moth is an excellent example, but can be distinguished from the hornet by its dark wing borders, which are lacking in the true hornet.

One of the best mimics is the wood wasp *Urocerus gigas*, but you can distinguish it from the hornet by the female's fearsome-looking ovipositor. The hoverfly *Volucella zonaria* is another hornet mimic, but has only two wings (not four).

ETHEROW PARK

Add plant-fringed lakes to rolling woodland above a meandering river, with views of wild moorland, and you have a perfect recipe for a visit to the countryside.

The lakes and woodland in question are those of Etherow Country Park, which extends up the Etherow river valley from Compstall, east of Stockport, Cheshire. Here we are at the cross-roads between the moors of the Peak District and the Cheshire Plain to the west. The River Etherow is the sinuous link between these sombre, peat-clad uplands and the mighty Mersey of the lowlands.

The lakes Drive into the car park at the western end of the Park, and you are immediately presented with a vision of open water stretching between ribbons of willow, tumbling masses of blackberry bushes, and clumps of young sycamore, oak, birch and ash. Canada geese and mallard jostle for the

Above: A view of Mill Lodge Woods in spring, with carpets of ramsons and ferns. Two Nature Trail booklets are available in the Information Office in the Park and all the paths are well signposted. The paths are suitable for pushchairs and even wheelchairs up to Keg House. Only a few of the 100 or so birds and 200 different plants to be seen in the Park are mentioned here, but with time (and a pair of binoculars) a visit to the Etherow Country Park can be a rewarding experience.

food visitors bring, and a pair of mute swans usually dignify the island by the café where they often nest.

Walk round the southern edge of the lakes, however, and you might well wonder where the river is. The large old mill standing below the water level on your right is the clue. It was built in 1826 as a cotton-weaving mill which used water-power harnessed by impounding the River Etherow in a large, shallow lake upstream of the weir (which you will see later), and then releasing the water steadily through a sluice into a canal excavated out of the side of the valley. This is the narrow lake by the café. The water then passed into the mill lodge in front of you and was used to drive, first, a water wheel, and subsequently water turbines. Now abandoned, the feeder canal and mill lodge make excellent aquatic habitats supporting a variety of plants and animals. The river, meanwhile, is hidden in the bottom of the valley below the mill.

Right: If you should fail to recognise ramsons–wild garlic–from its pretty white blooms, you'll soon find that its unmistakable smell announces its identity.

Below: Grey squirrel on a tree stump. Mammals in the Park are not easy to spot, except when the grey squirrels scurry about the trees. The occasional stoat or weasel may rush past the lucky visitor, while high pitched squeaks in the undergrowth signify a meeting of shrews, and a musty smell reveals the passage of a nocturnal fox.

Left: The lake and river in the Park are good habitats for a variety of insects–including the *Aeshna* dragonfly shown here. It is worth pausing for a while on the bridge by the weir to see what may fly past. Apart from the dragonflies and damselflies, you may be fortunate enough to see a dipper or a grey wagtail. The dipper, in fact, is a symbol of this meeting of upland and lowland, since it prefers fast-flowing water. Indeed, if you travel west you will not see the dipper again until you reach the Welsh Borders. In early summer you'll find the Keg Pond full of tadpoles but, since frogs are now so scarce in some areas, it is best to leave them where they are–don't take any tadpoles home in a jar. Watch them in their own natural habitat.

A search between the fishing points along the mill lodge banks reveals various emergent water plants. The blue-green leaves of reedmace, with their familiar dark brown seed spikes, can be distinguished from the flattened, bright green leaves of yellow iris. The similar sword-shaped leaf with crinkled margins is that of the sweet flag. The flowers of this are unmistakable, resembling as they do a small upturned, tapering, textured banana.

The riverside woodland If you have not the time or inclination to walk on into the Keg Woodlands, glance instead into those below the mill lodge, where they fringe the tumbling river. The native oak, alder, ash, and shrubs like guelder rose, hazel and even the occasional holly, display a jumble of colour and shape to please the eye. The ground cover is equally varied, with patches of dog's mercury competing with yellow pimpernel, wild strawberry and wild arum. The mouth-watering smell of wild garlic marks the damper spots, while the lush green leaves interwoven with the long, silky hairs of the greater woodrush, are characteristic of the acidic soils on the river bank.

'Stay-at-home' woodland plants, like the yellow archangel and wood speedwell, which find colonizing new habitats difficult, suggest that this small patch of woodland has probably been shaded with some sort of tree cover for several centuries. There have been changes, of course. Nettles have invaded, following disturbance; the alien sycamore, an aggressive colonist, has taken over parts of the wood; and one of the most abundant species of the whole Park, Himalayan balsam, is another introduction. This latter plant has spread rapidly up the river valleys of the north-west in recent decades, and can dominate woodland or stream-edge communities. Other names for this amazingly fast-growing and rather smelly annual are jumping Jack and touch-me-not, on account of the explos-

ive seed capsules, and policeman's helmet, a name which reflects the shape of the large pink, pendulous flowers.

The common birds in this woodland fringe, such as blue tit, wren, chaffinch and blackbird, are augmented in summer by willow warbler and blackcap. The constant contact calls and acrobatic manoeuvres of the long-tailed tit are always a delight to find. In contrast, turn back to the mill lodge to look for some of the water birds. There is nearly always a pair of great crested grebes by the small island here, where they may be seen diving for small fish, feeding their fluffy striped young or, in spring, engaged in their remarkable mating ritual.

A gourmet's delight Beyond the mill lodge, two successive bridges lead you to the main track along which you can return to the car park. Alternatively, continue along the bank of the canal to the weir. The path is bordered by a tall herbaceous community which is a gourmet's delight. There is the aniseed-smelling sweet Cicely, which is an ancient pot-herb now growing wild in northern Britain. The feathery leaves of pignut grow on the left of the path, while nearer the weir there is a patch of common mint among the rosebay willowherb and nettles. Even the latter are good to eat, made into beer or eaten young as a spinach substitute, although it is the elephant hawkmoth caterpillar which prefers the willowherb. Even the leaves of common dandelion, resplendent in the grasslands here, were once valuable in salads, and wild angelica, which indicates damper soils, is closely related to the commercial variety used for confectionery. Under the hawthorn hedge round the bulbous end of the feeder canal grows another old pot-herb called goutweed (referring to past medicinal uses) or ground elder (a reflection of its leaf shape).

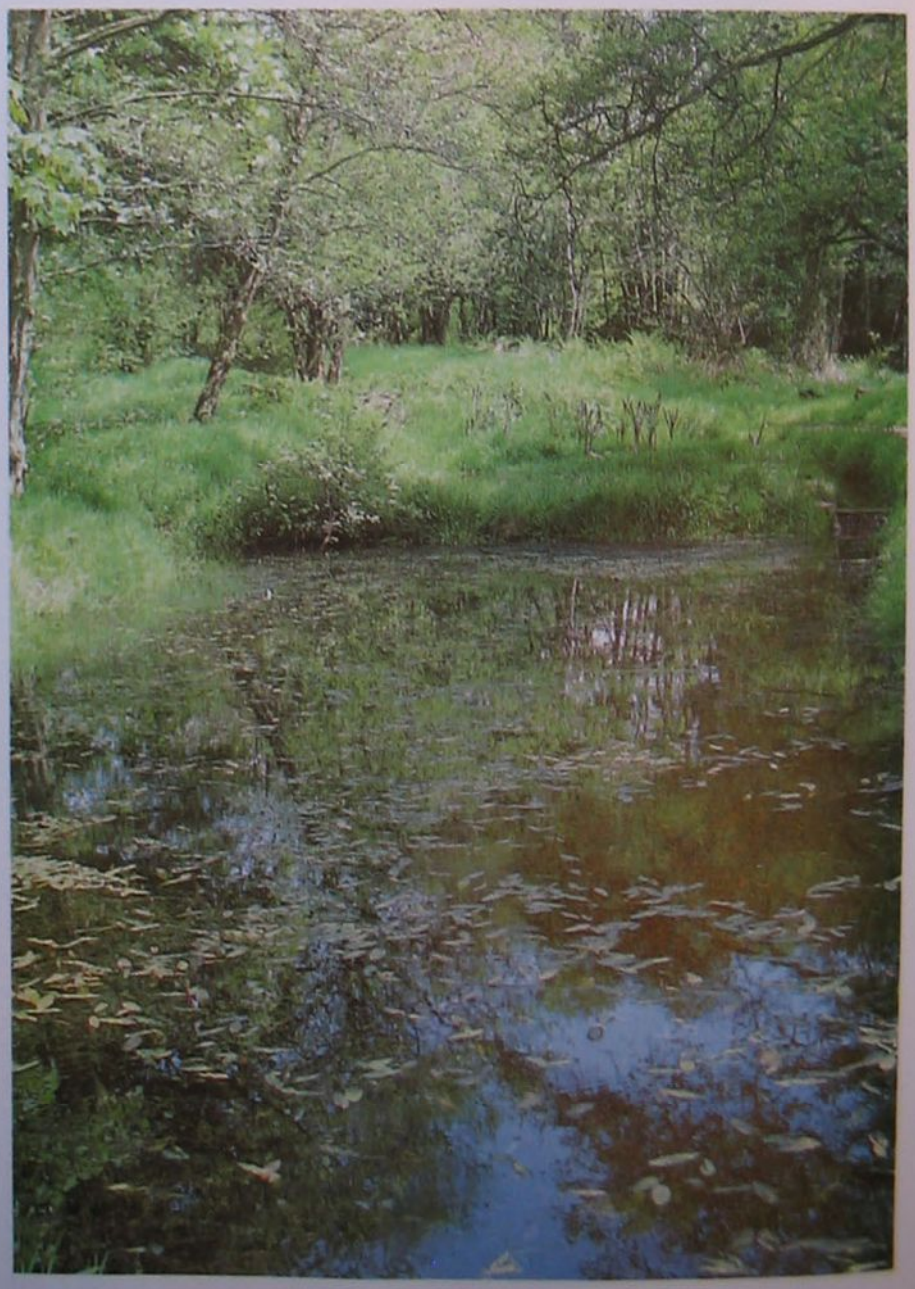
The Keg Woods Exploration of the Keg Woods, which extend from the Weir Cottages nearly a mile upstream, is particularly rewarding. You pass into the haze of a bluebell wood, at its best in May and June when the delicate perfume of the bluebells suffuses the air.

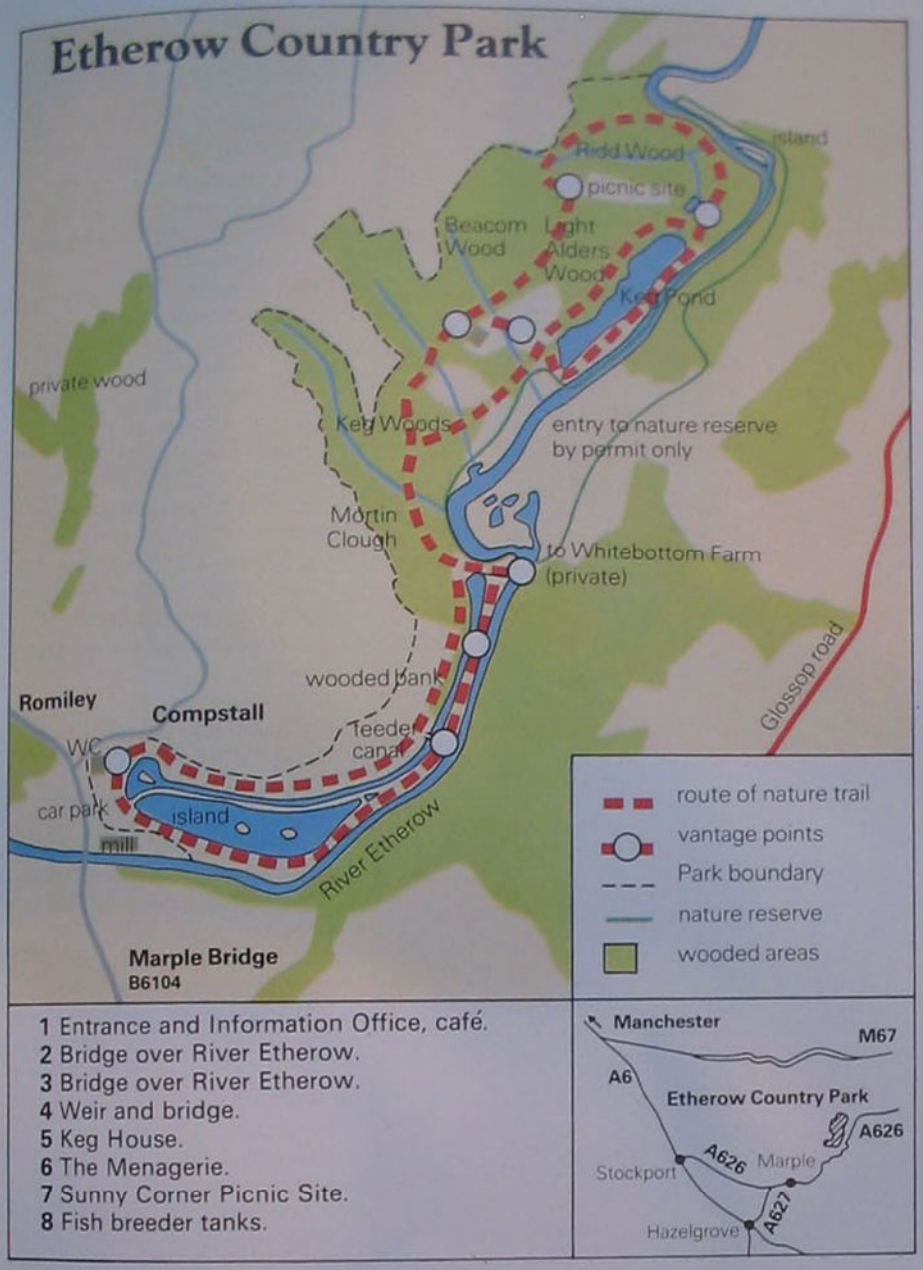
These woods were part of a hunting estate based on Keg House. Many of the trees are native – ash, pedunculate oak, alder and silver birch for example – but their roughly equal age in the first section of the wood suggests earlier felling, and either subsequent spontaneous regeneration or some planting. Native shrubs like the bird cherry, a northern species, and hazel are not abundant in this part of the wood. On the other hand, sycamore has invaded in some parts and the rhododendrons were planted to screen the drive. Stay on this path beyond Keg House and the Menagerie, and you will find a group of beech and silver birch planted close together on the right. The dense shade they cast precludes most flowering plants, but various fungi are abundant here, especially in autumn.

A little further, by Sunny Corner picnic site, a small larch plantation is a more familiar sign of modern woodland management. Beyond this, an open oak canopy is interspersed with a few planted Scots and Corsican pines. These

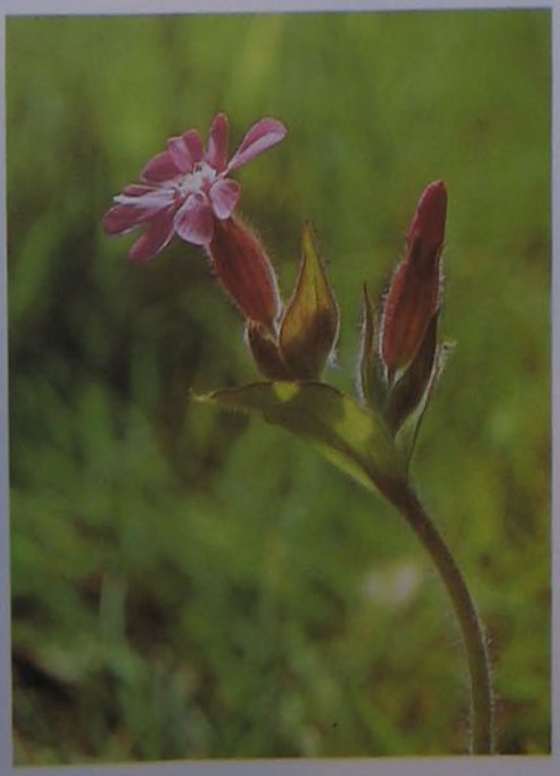
Above: Kingfishers can be seen in the Nature Reserve.

Below: A view of Etherow's fish tanks in spring.





1 Entrance and Information Office, café.
2 Bridge over River Etherow.
3 Bridge over River Etherow.
4 Weir and bridge.
5 Keg House.
6 The Menagerie.
7 Sunny Corner Picnic Site.
8 Fish breeder tanks.



Right: The carpet of spring flowers in Keg Woods is profuse. The pink of red campion (shown here) mixes with the white flowers of greater stitchwort on the drier slopes, while crushed ramsons fringe the track. Wood anemones are sprinkled among the carpets of yellow shiny lesser celandine and, later, wood avens and the white flowering spikes of the annual enchanter's nightshade replace the earlier display. Many of these species have a poor colonizing ability and are thought to represent areas of ancient broadleaved woodland. However, as in the Mill Lodge Woods, the effects of man's activities are conspicuous. As usual in any countryside habitat, don't pick any of the plants that you see.

appear mostly to be of similar age. In a natural situation there should be lots of hazel and other shrubs like guelder rose and hawthorn; by asking yourself whether such appropriate shrubs are present, you can start to work out the results of past management practices.

Birds in the Keg Woods are as diverse as the plants. Not only are all the common woodland species readily seen, but you may also be lucky enough to find the lesser as well as the great spotted woodpecker, the nuthatch (watch out for this attractive species on the Keg House bird table in winter), and the spotted flycatcher. The wood warbler, which is a summer visitor, is an example of an upland woodland bird, and the tiny goldcrest frequents the areas of pines and larches all year round. This latter species feeds on insects, some of them of minute size. The female goldcrest lacks the fiery colour of the male.

The mounds of bramble, nettles, elder, and the more open grassy and marshy areas below the first picnic site are likely places to find such butterflies as the orange tip, small tortoiseshell and red admiral. The berried shrubs also attract large flocks of visiting fieldfares and redwings in winter.

The winter fish pond If you continue on the woodland path beyond Sunny Corner, or take a short cut through the Menagerie, you will discover the splendour of the Keg Pond. With the woodland above and the fringing alders near the river, this is an excellent sheltered area for finding dragonflies, like the large brown aeshna, or the metallic blue and green smaller damselflies; both dragonflies and damselflies lay their eggs in the water.

The water abounds with small animals. Small twigs or stones moving on the bottom are the cases of caddisfly larvae; water beetles surface for their silver air bubbles; small black flatworms ooze across the stones; and snails cling to the vegetation.

Cover for these animals, and for the numerous coots, is provided by an extensive stand of the water horsetail. Amphibious bistort and pond-weeds coat much of the surface, and the less common large bittercress grows in the mud at the water's edge. The more productive habitat here is a result of the clean spring water (rather than river water) which feeds the pond and the fish breeder tanks upstream from it.

The marshes Below the path from the Keg Pond back to the first picnic site, there is an extensive area of marsh, too wet to permit pedestrian access, which is managed as a Nature Reserve by the Cheshire Conservation Trust. You can see the swarms of bright yellow kingcups in spring, interspersed with reeds, alder, willow and other marsh plants. The Reserve attracts various ducks and waders in winter, and a flash of bright blue identifies the resident kingfisher. Permits are required for entry to the Reserve and the hide (the address is available at the Information Office).

Shell features: the working parts

The valves are held together by adductor muscles, the hinge (**1**) and the ligaments (**2**, **3**). The adductor muscles are attached to the valves and when removed leave muscle scars (**4**). The ligament may be visible outside the shell (external, **2**) or hidden inside (internal, **3**). It can be set in a pit known as the chondrophore (**5**). In primitive bivalves the hinge comprises taxodont hinge teeth (**6**), while in more advanced forms it comprises cardinal (**7**) and lateral teeth (**8**). Some species lack teeth.

Shell features: growth points

The valves grow from a point of origin at the top of the shell, represented in the adult by the pointed beaks (**9**), which lie inside the umbones (**10**). The umbones are thus the oldest parts of the shell. The bivalve's mantle secretes the valves and is attached to them at the pallial line (**11**). The margins (**12**) are the newest parts of the shell and the pallial sinus (**13**) represents an infolding of the mantle.

BIVALVES OF BRITAIN

Most seashells on a sandy beach come from bivalve molluscs. Here we look at the whole range of British bivalves.

Bivalves produce the majority of the shells we find on the sandy shore, and form a large and important class of molluscs. As their species in our waters number nearly 200, it is interesting to take an overall look at the class. We begin with some of the simpler features of bivalve anatomy, which may solve several mysteries for the beginner, and indicate how the different animals are compared.

Bivalve anatomy It is important to note, first, that each bivalve has a front and a hind end, as well as left and right sides. The hinge between the two valves (shells) is always at the back (the dorsal side). Close to the hinge is an external protuberance known as the umbo (plural umbones). Since there are two valves, there are two umbones facing each other; each terminates in a 'beak' that points inwards. The mollusc lies within the valves, with its head at the front (anterior) end and its foot on the lower or ventral side. In advanced bivalves, such as razorshells, the foot protrudes at the posterior end.

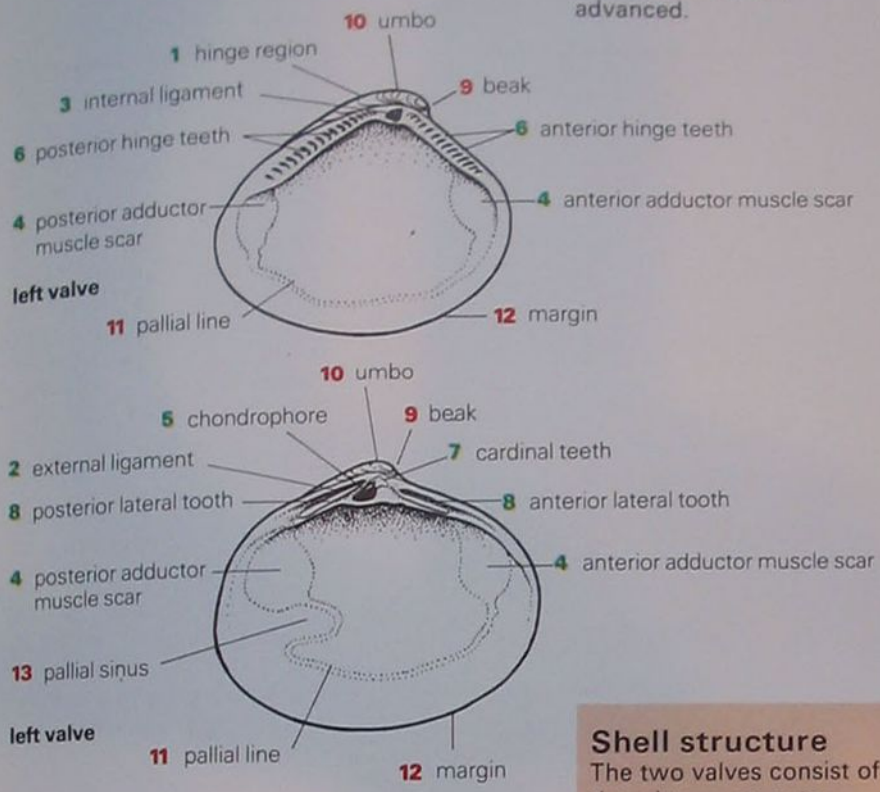
On the inside of the shell you can see various marks which correspond to the manner in which the animal is attached to the shell. Conspicuous among these is the pallial line, which runs roughly parallel to the outer edge of the shell; it marks the extent of the attachment of the valve to the mantle, which is the animal's outer skin. Secondly, the shells are held together when closed by two muscles (adductor muscles), the attachment points of which can be seen as scars on the inside of almost all bivalve shells.

Above left: File-shells are related to scallops, but their shells are narrower from the ventral to the dorsal side, and deeper from the head to the foot end. They do not have the square corners or 'ears' of the scallops. The shell surface, as can be seen in this picture, shows the characteristic radiating ribs and concentric ridges. The mass of tentacles gives the file-shell a dramatic appearance: these are organs for the capture of plant plankton from the sea.

Right: A spiny cockle, hurriedly seeking refuge after its release from capture. It opens its shell and lets out a large pink foot, with which it immediately starts to burrow for safety in the muddy sand.

Shell identification features

These two drawings show the internal features of bivalve shells which are used in classification. The upper one is a more primitive type, the lower one more advanced.



Primitive bivalves with taxodont hinge teeth (upper diagram): nut shells, ark shells and dog cockles. Oysters are also primitive but lack teeth.
Advanced bivalves with cardinal and lateral teeth (lower diagram): cockles, Venus shells, wedge shells, tellins and razor shells. Piddocks lack teeth.

Shell structure

The two valves consist of three layers: an outer periostracum like a horny skin; a prismatic layer to give bulk and strength; and an inner, nacreous layer of mother-of-pearl. The outer surfaces are sometimes ornamented with radial ribs and concentric ridges.

The primitive bivalves The first group of bivalves to evolve is thought to have been the sub-class Palaeotaxodonta. These are widely distributed in the world's seas, burrowing into soft substrates and feeding with two pairs of palps which emerge at the head end. They are generally small: one British example, the nut shell *Nucula nucleus*, grows to about 13mm ($\frac{1}{2}$in) in length. The hinge between the two valves is known as a taxodont, because numerous small teeth run forward and backward along the articulating surfaces.

Attached to hard surfaces Most bivalves that attach themselves to hard surfaces such as rocks are placed in the sub-class Pteriomorpha. The first examples are ark shells. The group also includes the saddle oysters, whose left and right valves are strikingly dissimilar. Indeed, the right valve looks incomplete for it has a large hole in the centre; through this hole a tough bunch of threads (the byssus filament) passes out to attach the animal to the rock. This sub-class also includes the dog cockles with their thick, heavy shells, despite the fact that they are burrowers.

About 12 species of the mussel family are found in British and Irish coastal waters, attached to hard substrates by their fine brown byssus filaments. Right and left valves are similar, and a distinguishing feature is the location of the beaks, which are always towards the front of the animal.

Near relatives of the mussels are the wing oysters (*Pteria*) and the fan mussels (*Pinna*). *Pteria* provides an excellent example of a feature of a bivalve shell known as the 'ear'–a wing-like extension along the axis of the hinge. A long ear reaches out towards the back, and there is a shorter anterior ear.

The fan mussel is the biggest British bivalve, reaching up to 48cm (20in) in length. It has large, triangular shells which are similar to one another and resemble fans.

There are three species of the oyster in our waters and these, too, belong to the attached bivalves. They do not, however, have byssus threads, but instead are actually cemented to the rock by their left valve. The valves themselves are solid and heavy, and are sometimes honeycombed by small holes made by boring sponges, or covered by encrusting animals.

The last group of attached bivalves consists of the scallops and file shells. The former (sometimes pronounced 'scollops') are normally attached only in their young stages: a byssus thread passes round a notch in the forward pair of 'ears'. The scallops are perhaps the best known example of bivalves with prominent 'ears'–they jut out on the hinged side of the animal, making a straight edge. Adult scallops are free-living, and swim by flapping their valves.

Freshwater bivalves The best example of these is the freshwater mussel *Anodonta cygnea*; the group as a whole, known as the sub-class Palaeoheterodonta, also includes

some marine species, but none occur in our coastal waters. The oval or circular shells are similar to one another; there are two adductor muscle scars, and a small number of teeth on the hinge.

The master burrowers A wide range of bivalves, from cockles to razor shells and from clams to shipworms, are placed in the sub-class Heterodonta. It is the group whose members are specially equipped for burrowing, possessing long siphons so that they always retain access to fresh sea water, no matter how long or deeply they stay beneath the sediment. The hinge is often well developed, with two types of teeth: large cardinal teeth, placed just below the beaks, and smaller lateral teeth along the back edges of the valves.

Cockles form a major section of the group, with 11 British species. Their plump valves are unmistakable, but accurate distinction between the species depends on a careful examination of the external ornaments–the scales, spines and the 'waves' (crenellations) on the shell margins, as well as the form and number of the radiating ribs.

Next come the Venus shells and their allies, a large group with 19 British species. These are robust, attractive bivalves with similar valves whose beaks lie in front of the midline, pointing forwards and slightly inwards.

The nine species of trough shells and otter shells include some of the commonest British bivalves. They are an example of bivalves that have both internal and external ligaments–the rubbery structures linking the valves.

About 24 species of wedge shells and tellins occur in Britain. Most have equal left and right valves, more lightly constructed than those of the cockles, and often slightly twisted in the posterior region. Related to these are the pod-shaped razorshells.

Rock borers (*Hiatella artica*, for example), piddocks and shipworms are also included in the Heterodonta. These lifelong raspers and burrowers cut into rock, hard mud, wood or other substrates, and are among the most highly specialised bivalves. Their hard, serrated shells gape open at front and back, allowing the body to extend in either direction, the foot at the rear and the part bearing the siphons at the front.

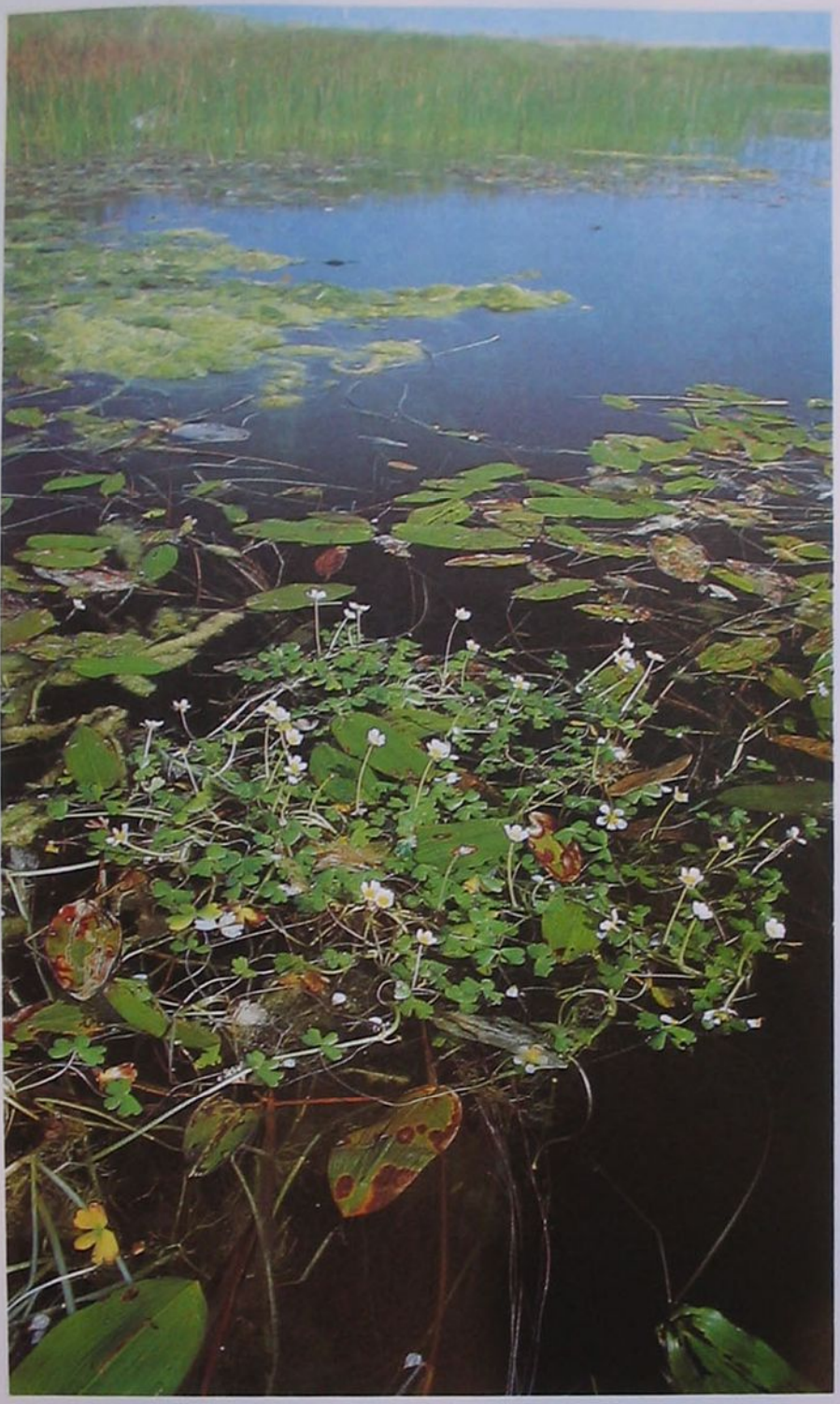
Above: A queen scallop with its valves open. Inside, its many eyes can be seen, like a row of bright beads.

Right: Banded wedge shells (*Donax vittatus*) burrowing. The shell is ornamented mainly by external lines and grooves. Inside, each valve bears two cardinal teeth, and there are two sets of lateral teeth.

Below: The sand gaper is a thin-shelled burrower; its left valve (seen here) is smaller than the right.

Unequal valves A final sub-class, the Anomalodesmata, is represented by 14 somewhat rare species. The lantern shells and Pandora's boxes display unequal shells, while the other members, the porymas and cuspidarias, are delicate-shelled animals that live in deep water. They are remarkable in being the only carnivorous bivalves in British waters. They catch small marine animals by sucking them into their mantle cavities, where they proceed to digest their victims.

The British fauna includes nine species of lantern shells and Pandora's boxes, and five of the carnivores.



BROAD LEAVED PONDWEEDS

Look beneath the floating leaves of a pondweed and you may find that the leaves below have a quite different shape from the ones on top.

Above: The large floating leaves of the broad-leaved pondweed (*Potamogeton natans*), here seen with the much smaller, lobed leaves of the common water-crowfoot (*Ranunculus aquatilis*). The much narrower submerged leaves, which cannot be seen here, appear in the spring before the floating leaves unfurl. Once the latter start to develop, however, they may shade out the submerged leaves and become the predominant source of chlorophyll.

To most people, pondweeds look to be no more than a collection of leaves floating on a stretch of fresh water–hence their rather disparaging name. To the various animals living there, however, pondweeds are extremely important plants, performing many essential roles.

In Britain, broad-leaved pondweeds (as distinct from the less important narrow-leaved kind) can be found in a wide range of aquatic habitats: from natural lakes and rivers to man-made reservoirs, canals, drainage ditches and ponds. They are the primary source of food for many insects and fishes, and they improve the quality of the water they inhabit by oxygenating it and absorbing excess nutrients. Pondweeds are also important as sites for fishes to lay their eggs and for microscopic algae to colonize. The eggs and algae are often eaten by insect larvae which, in turn, fall prey to larger insects, amphibians, fishes and birds. Pondweeds are, therefore, important not only as a source of food in themselves but also as a 'larder' to be raided by hunters.

Aquatic herbs Broad-leaved pondweeds belong to the genus *Potamogeton*, a group of aquatic herbaceous plants with representatives in all five Continents. They inhabit fresh water and are known to live in brackish conditions as well, though this is rare. Some species are occasionally capable of surviving out of water if the river or pond dries up, though they cannot normally complete their life-cycle in such an environment.

The flowers of a pondweed are small and insignificant, borne on flower spikes that appear above the surface of the water. Pollination may be via wind, water or insects. Once fertilisation has occurred the fruit stalks often bend back into the water, allowing the fruits to mature at or below the water surface.

There are 11 species of broad-leaved pondweed in Britain. Four of these are submerged species, the only time they appear at the surface being during the flowering season. The other seven species all have some floating leaves and some submerged leaves and, in all but one case, these two different shapes–a phenomenon known as heterophylly.

Variable leaves All the British species of pondweed that exhibit heterophylly have broad floating leaves and much narrower submerged leaves since these are the most efficient shapes for their particular situations. Broad leaves float better, while narrow leaves are better under water because they offer less resistance to water flow. Furthermore, the broad shape of a floating leaf allows it to catch the maximum amount of sunlight and so makes it more efficient at photosynthesis. Narrow leaves, however, are more efficient photosynthesisers in the often murky waters below the surface.

Among Britain's six pondweeds showing heterophylly, three tend to have more sub-

merged leaves than floating ones. These species are the reddish pondweed, the various-leaved pondweed and the leafy pondweed. Two species–the bog and broad-leaved pondweeds–have more floating leaves than submerged. In the remaining species, the Lodden pondweed, neither type of leaf predominates.

The proportion of the different leaf types varies, however, with the depth of water in which the plant lives. The proportion of submerged leaves becomes greater in deep water, while in shallow water the floating leaves become more numerous and the submerged leaves may even be entirely lacking.

Plants with heterophylly The reddish pondweed, named after the reddish tinge sometimes found on its leaves, occurs in scattered locations throughout Britain, though it is rarely common. It prefers slightly acid, peaty water and thrives in lakes, rivers and ponds with a large amount of organic matter on their beds. The plant dies back in late summer and then begins to grow again in early winter. The young submerged leaves are strap-shaped and membranous; as they age they elongate, sometimes reaching up to 20cm (8in) long. The floating leaves appear only during the summer and are much more opaque than the submerged ones.

Superficially, the various-leaved pondweed is similar to the reddish species, but it exhibits heterophylly much more readily–hence its name. It also has a similar distribution, and the two species are quite often found together, though it shows an even greater preference for acid water.

The leafy pondweed, which is also known as the American pondweed, is native in Europe to just one area–the Outer Hebrides, where it was discovered only during the last few decades. It is a very distinct species, with flattened stems and translucent leaves which are about 20 times longer than they are wide.

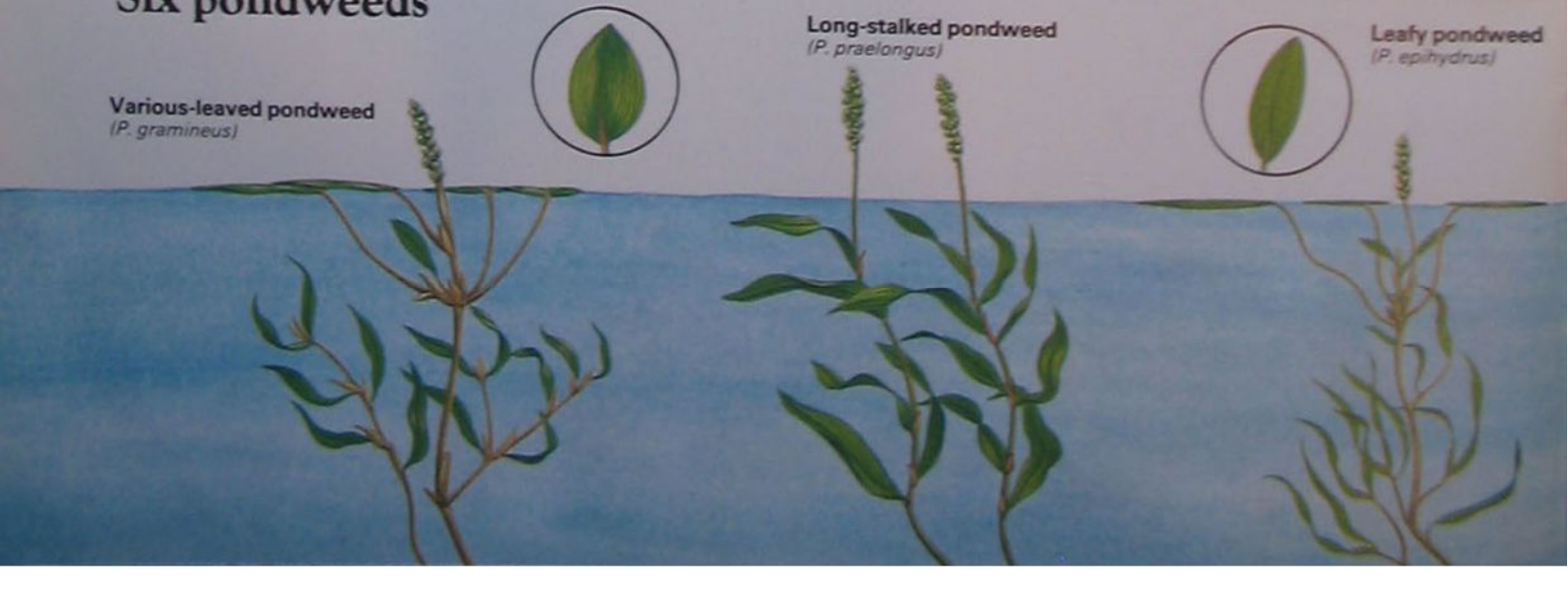
The broad-leaved pondweed is the most common member of this group in Europe. It can grow in a wide range of habitats, being equally at home in both acid and alkaline waters. Its submerged leaves are long, narrow and opaque–unlike those of other pondweeds, which are translucent. The floating leaves are perfectly adapted to sitting on the water surface because they have two flexible, jointed wings where the leaf blade meets the stalk.

The two remaining species showing heterophylly are the bog and Lodden pondweeds.

Above: The flower spikes are borne clear of the water to allow fertilisation to occur in air.

Below: The bog pondweed (*Potamogeton polygonifolius*) in typical habitat.

Six pondweeds

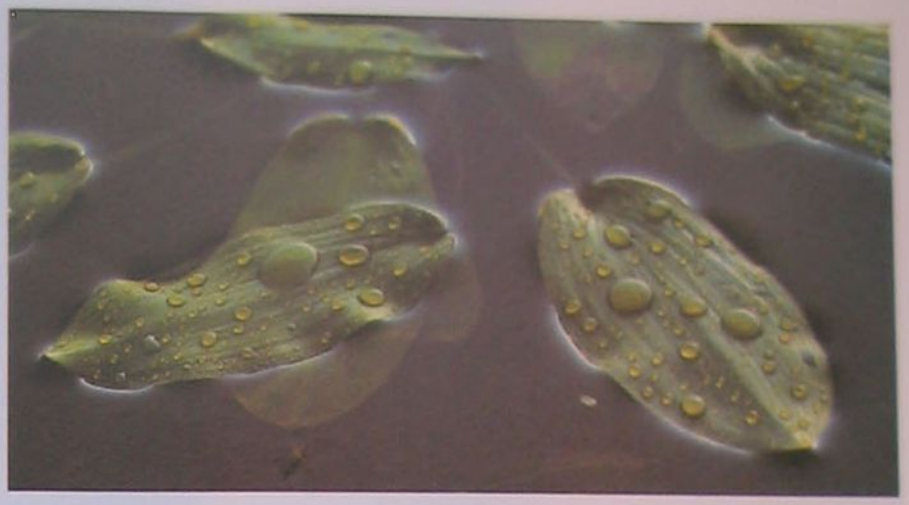


The former prefers upland or acid water and is most often found in bog pools and shallow flushes. The latter plant is one of the most beautiful of the large British pondweeds, having very thin translucent leaves and an attractive pattern of veins. The Lodden pondweed is found in certain tributaries of the Thames, the Dorset Stour and the Bristol Avon, and has a high resistance to pollution.

Submerged species Of the five British broad-leaved pondweeds not displaying heterophylly, four are submerged species. The smallest and most easily identifiable of these is the curly pondweed because its leaves have distinct teeth along the margins. A robust species, it is well able to resist pollution and other disturbances to the environment.

The three larger submerged species are the shining, long-stalked and perfoliate pondweeds. The perfoliate prefers deep water and is common in slow-flowing rivers, canals, ponds and lakes, particularly in central England. The long-stalked species is named after the way in which the flowers are borne on very long stalks well clear of the water. The shining pondweed is the commonest pondweed in lowland rivers of southern England but it is rare elsewhere.

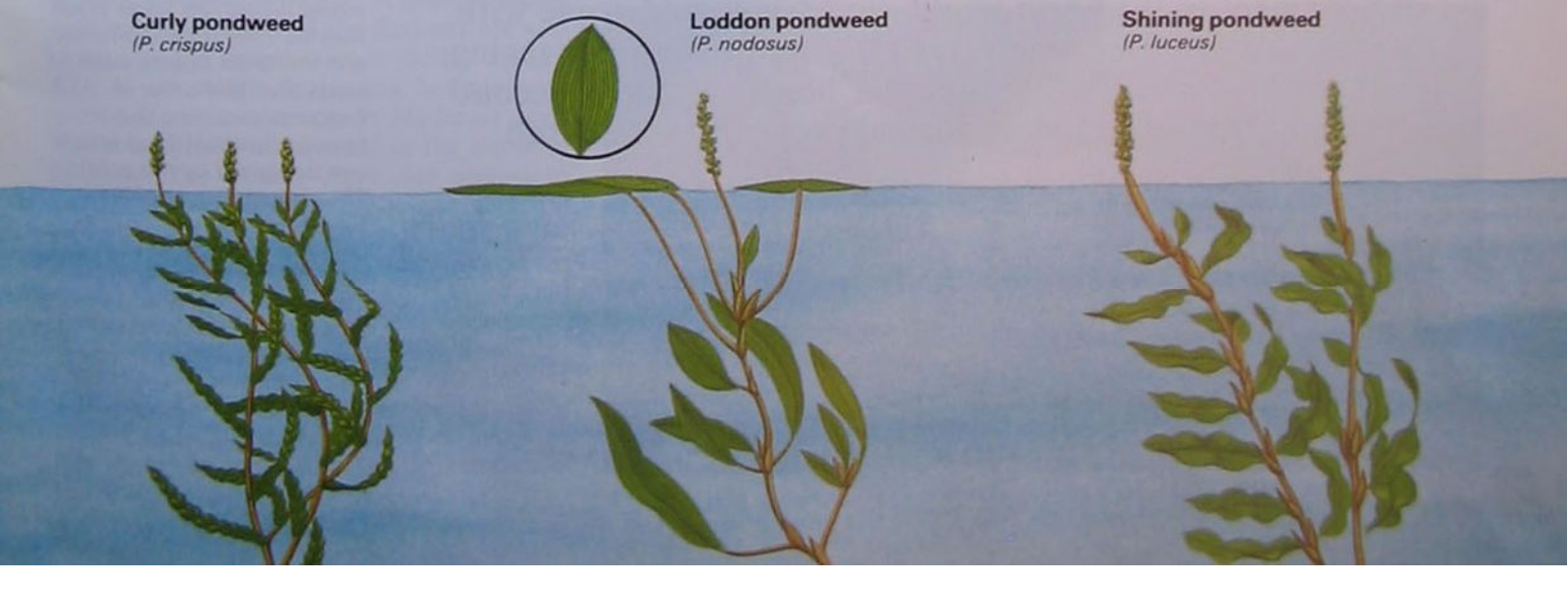
Fen pondweed The odd one out among British broad-leaved pondweeds is the fen pondweed, which is neither a submerged species nor does it exhibit heterophylly. It shows a distinct preference for the Fens.



Above: The parallel veins on the leaves of this pondweed are typical of the group.

Right: A flower spike of broad-leaved pondweed. Each tiny flower, no more than about 4mm across, consists of four green petal-like structures called perianth segments. Inside them lie the stamens and styles.

Below: Reddish pondweed (*Potamogeton alpinus*). Notice how its submerged leaves are much narrower than the floating ones.



Curly pondweed
(P. crispus)

Loddon pondweed
(P. nodosus)

Shining pondweed
(P. luceus)

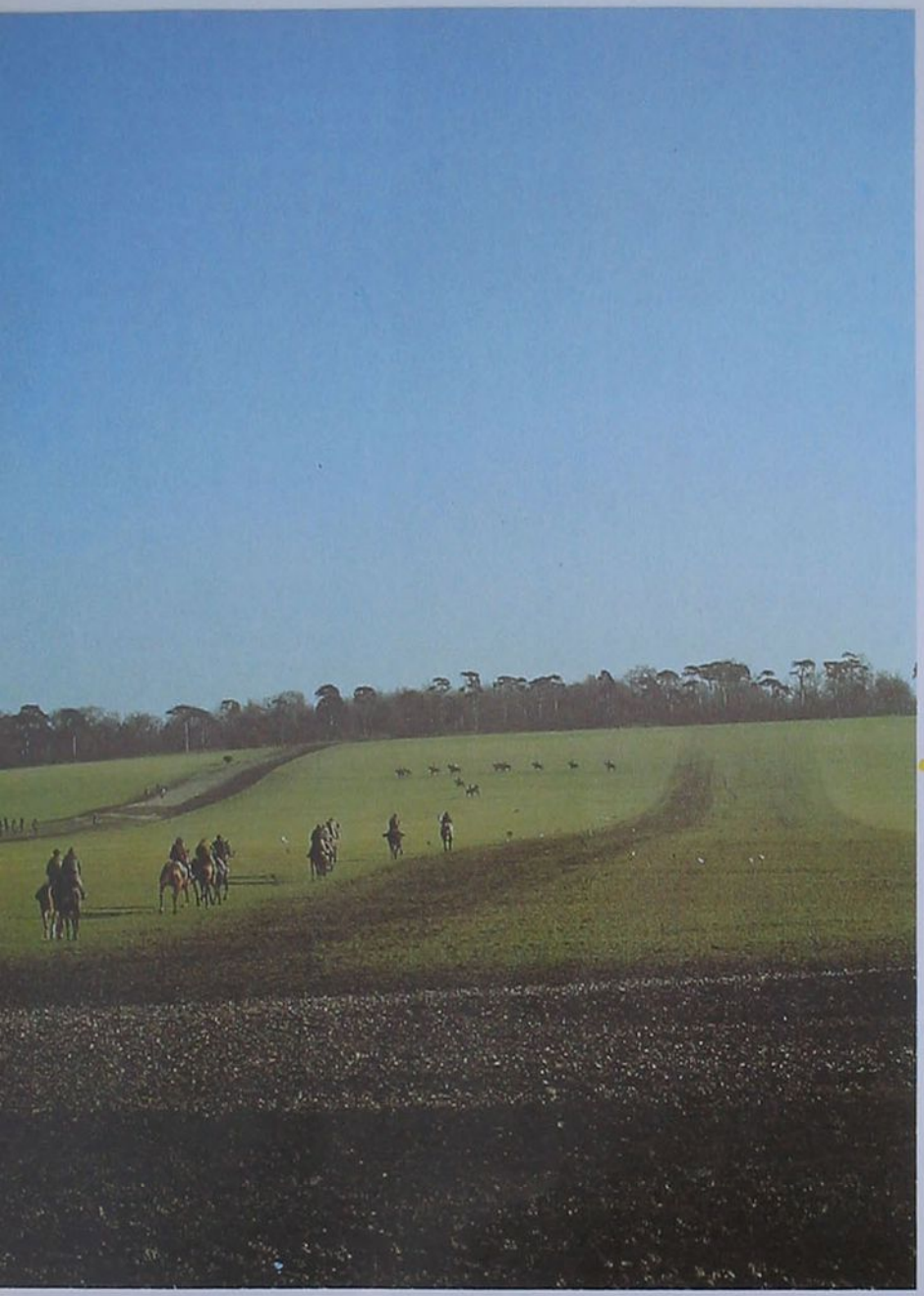
THE THOROUGHBRED: TOP RACING MACHINE

The Thoroughbred horse has been described as man's crowning achievement in the horse world–and few would argue with that. Developed over nearly five centuries, mainly for racing, it has exerted an influence on other breeds of horses second only to that of its own principal progenitor, the Arab.

In appearance the typical modern Thoroughbred combines the essential features of equine power and speed with a beauty and aristocratic air unsurpassed by any other breed of horse. The relatively small, finely modelled head with its broad forehead and dished (slightly concave) profile tapering to a narrow muzzle, the gracefully arched neck, the sloping shoulder that allows the long raking strides, the short back and well-muscled strong quarters atop long, slender legs–all present a picture of elegant and speedy strength.

The Thoroughbred is noted, too, for the silky quality of its coat through which the superficial facial blood vessels show clearly. Modern Thoroughbreds stand from about 14 hands (142cm/56in) to over 17 hands

Above: Horses training at Newmarket. It was James I who established Newmarket as a centre for racing in England, and the town's reputation was further enhanced by Charles II who inaugurated and rode in the Newmarket Town Plate. Horse racing has taken place here for over three centuries, and the town boasts more studs than any other in England, including the famous National Stud which can be visited by the public. The annual Thoroughbred sales attract buyers from all over the world. Newmarket is also famous as the home of the Jockey Club, the organisation that controls racing in Britain.



(172cm/68in), but those involved in racing, with a few notable exceptions, average 16 hands or more. The colours are principally bay or brown, with a few greys and blacks. Piebalds and skewbalds are never found.

Ancient sport Racing has been part of the English country scene for centuries. The early Britons probably indulged in chariot racing with native ponies, and the Romans are said to have staged ridden races in the 4th century AD. In the Anglo-Saxon era teenage boys competed as jockeys, and in Medieval times Galloway ponies were raced in the north of England. The Middle Ages also appear to have seen the first importation of significant numbers of Eastern horses (Barbs, Arabs and Turks) for racing. The great authority on the Arab horse, Lady Wentworth, claimed that Arabs were raced in covered hippodromes in such places as Dorchester and Caerleon (near Cardiff) as long ago as the 4th century AD–but she was an Arab horse enthusiast and at times her enthusiasm overshadowed her regard for accuracy. The significance of these Eastern importations, no matter when precisely they began, is that they laid the foundations for what was to develop into the modern Thoroughbred.

Sport of kings Not until the Tudors did racing achieve any real status with more than casual interest being shown in selective breeding for speed and racing ability. Henry VIII founded the influential Royal Paddocks at Hampton Court where imported horses from Spain and Italy (almost certainly with a preponderance of Arab and Barb blood) were interbred with native royal stock, and Elizabeth I founded the Tutbury Stud in Staffordshire and followed her father's policies of importing horses for breeding. After the royal example, the aristocracy became deeply involved in horse breeding and continued to import horses with Eastern blood. So, gradually–almost accidentally–the foundation of the Thoroughbred was laid.

Following the dispersal of the royal stables during the Cromwellian era, records were lost or destroyed and it was not until the last quarter of the 17th century that serious breeding started once more. A significant number of Arab, Barb and Turk stallions were imported for their remarkable prepotency (ability to stamp their own characteristics on succeeding generations). This was to overcome the bastardisation of local stock that had resulted from centuries of indescriminate cross-breeding. Serious breeders soon realised that the prepotency of Arabs was the means of establishing stock that would breed true to type.

Romantic ancestor At that time three stallions were imported which have come to be regarded as the principal 'founding fathers' of the modern Thoroughbred: the Byerley Turk, the Darley Arabian and the Godolphin Arabian. All three in their ways had romantic backgrounds.

The Byerley Turk was captured by a Captain Byerley at the Battle of Buda against the Turkish army in the late 1680s. He was later ridden at the Battle of the Boyne and then sent to stud, first in Durham and finally in Yorkshire. Through his son, Jigg, a male line can be traced unbroken down to famous

Below: An Arab horse. Up to 80% of the modern Thoroughbred's genes derive from just 3 original Arab ancestors, giving a genetic uniformity which makes the Thoroughbred a dominant influence in breeding.

Top right: Arab horses such as this are known for their fiery yet kindly nature.

Left: Thoroughbreds grazing peacefully with their foals. Numerous breeds throughout the world are crossed with Thoroughbreds to upgrade the stock. In Britain one of their uses has been to create the British Riding Pony–a pony used almost exclusively in the show ring by children. These ponies have been developed by crossing Arabs and Thoroughbreds with British native ponies–notably the Welsh–to produce exquisite looking, beautifully moving fine ponies. However, they are often highly strung and unsuited to all but the best of child riders.

20th century racing Thoroughbreds such as The Tetrarch.

The Darley Arabian was sent from Syria to stand at stud in Yorkshire, where he sired a relatively small number of mares; by one –Betty Leedes, belonging to Leonard Childers–he sired what has come to be recognised as the first really top quality racehorse, Flying Childers who founded a line which descended through Markse to Eclipse–one of the all-time racing 'greats'.

The third of the three foundation stallions, the Godolphin Arabian, was foaled in the Yemen in 1724 and died 29 years later at Lord Godolphin's home, Gogmagog. He had several famous owners during his life; that he took his last owner's name points to one of the difficulties of historians in attempting to work out the pedigrees of many early horses and their descendants. They frequently took their owner's name until they were sold, when they acquired the name of their new owner.

However there is no doubt about the identity of the three horses and they are of such importance because all present-day Thoroughbreds can be traced back to one of them. Other Eastern stallions were also important, but in the main their direct male line has died out.

Lady Wentworth in her famous work *Thoroughbred Racing Stock* analysed the pedigree of Bahram, winner of the 2000 Guineas, Derby and St Leger in 1935. She showed that he had, among others, 29,232 crosses of Godolphin Arabian blood, 44,079 of Darley Arabian, 64,032 of Byerley Turk, and 112,667 of another early stallion, the Leedes Arabian.

The appearance and size of the modern Thoroughbred has become more or less standardised. In the early days the Arab appearance was naturally more apparent and the size rarely exceeded 15 hands

Below: A hunter mare and her foal, and (right) jumping in the working hunter class. In the testing conditions of the real hunting field, the ideal horse for the cream of hunting 'countries', the 'Shires' of Leicestershire, is a good Thoroughbred as it has the speed, the jumping ability and the courage to gallop across the wide fields and tackle the bigger fences found in that area. The same abilities are required in the all-round sport of horse trials such as Burghley and Badminton.

(152cm/60in). Although the average height of today's racehorse is 16-17 hands, not all Thoroughbreds lie within that range. One of the most famous of 20th century sires, Hyperion, winner of the 1933 Derby, stood a mere 15 hands 1½in. Some horses stand over 17 hands but they frequently have leg trouble –the relatively slender legs of the breed are unsuited to carrying the weight of a bigger frame. (Many experts feel that entering two-year olds for training before their physical maturity at the age of five years adds to the likelihood of leg problems.)

The breed evolves Changes have taken place over the centuries. The Thoroughbred is now a much more rangy horse than the Arab from which it is derived. While retaining the Arab-like 'dished' profile to a large extent, the head has become proportionately longer. There have also been some anatomical changes. The skeletons of Arab horses have five lumbar vertebrae, 16 caudal vertebrae and usually 17 pairs of ribs. Thoroughbreds generally conform with most other breeds in having six lumbar vertebrae, 19 (sometimes 18) pairs of ribs, and 18 tail vertebrae. Occasionally there is a reversion to the Arab origins in individual horses: for instance, a Thoroughbred stallion Solario was found at post mortem to have 17 pairs of ribs–the typical Arab number.

So much for racing Thoroughbreds. In show rings up and down Britain the most elegant Thoroughbreds are seen heading the line in the hack classes, where their superb looks and graceful movement may be equalled, but rarely surpassed, by animals with a more generous helping of Arab blood.

Thoroughbred hunters tend to be rather more heavily built and workmanlike to stand the hurly-burly of the hunting field, and ideally they have a slightly higher knee action which takes them over the rough ground of the hunting field more safely. In the heavyweight hunter classes, the versatility of the Thoroughbred is frequently illustrated. Many champion heavyweights are bred by crossing Thoroughbreds with heavier breeds such as the Cleveland Bay or even with a draught horse, such as the Suffolk. The Thoroughbred supplies the quality and the movement, while the heavier blood gives the substance.

Temperament If a Thoroughbred can be criticised on any count, it must surely be on this. Many Thoroughbreds are highly strung and they require more tactful handling than most other breeds. This temperament is used to advantage in racing and other competitions but in some areas, such as dressage, it can be a disadvantage.

Thoroughbred blood has been used in this country to create the British Riding Pony. It has also sometimes been used to upgrade some of the native breeds, but on the whole to their detriment as it tended to reduce the hardiness factor so essential in the Mountain and Moorland breeds.

The Thoroughbred–built for speed

BRITAIN'S BIRDS CLASSIFIED

Few groups of animals are so immediately recognisable as the birds, but what are the differences which separate one bird order from another?

Above: A fulmar in flight. White sea-birds are not all closely related to gulls: the fulmar is one of the petrels, a primitive order of birds that are distinguished by their 'tube-noses'. The other white sea-bird on British and Irish coasts that is not related to gulls is the gannet, which belongs with the cormorant and shag in the order Pelecaniformes.

Below: This black-tailed godwit, on the other hand, does not look like a gull, but belongs to the same order as the gulls, the Charadriiformes. The 16 British families in this order include the Scolopidae family of long-legged waders, to which godwits belong, and the Laridae–the gulls and terns.

Modern bird classification is intended not only as a 'filing system' for easy reference–it is an attempt to show the natural relationships between groups of birds. As in all systems of classification, it can be depicted as a family tree. Like all family trees, the lineage of birds can be viewed from above–from the 'twigs' down the 'branches' to the 'trunk'–or from below, starting at the trunk and following its divisions into branches and then twigs. The twigs represent the various species of birds.

Of these two views, the one from the trunk upwards would in many ways be more satisfying. For if we had sufficient information, for example from fossils, we would be able to construct a classification that was perfectly faithful to evolution. Species, genera, families and orders would be purely natural ones and the taxonomist's work would be done for ever.

Unfortunately, the fossil record is far too full of gaps for this to be remotely possible. Thus bird classification has to depend heavily on the view from the top of the tree, arranging species, genera and families for the most part by what can be examined in a specimen today.

Confusing similarities Two important features are common to all birds: feathers and a pair of wings. These structures have resulted in a number of other common features that conform to the needs of an airborne life–such as lightweight bones, a flexible neck and a streamlined body. These adaptations so dominate the appearance of birds that, as a class, they are far more uniform than other well-known classes such as insects, mammals or reptiles. It follows that the features that distinguish one order of birds from another are often relatively minor. (Species, of course, can usually be distinguished most easily by their plumage patterns.)

The problem of classification into orders is increased, however, where, during the course of evolution, widely separate groups have developed, but which show much the same characteristics. This happens when various birds have a particular activity or habitat in common. The hobby, the swift and the swallow, for example, all live by fast flight, and in each species evolution has emphasized long, sickle-shaped wings with long primary feathers to achieve great speed. Other obvious features (beak and claws) quickly remove the hobby from this trio, but it takes an examination of, for example, the feet to place the swift and the swallow into different orders. The swift has all four toes pointing forward, while the swallow has three toes forward, one back. It is this relatively obscure feature that places swallows in the vast order of perching birds, the Passeriformes, while swifts are not even closely related–they belong with the hummingbirds of the New World, in the order Apodiformes.

Besides the sickle-shaped wings, many other examples can be cited of unrelated birds which have evolved to look alike. This is known as parallel evolution. Just as puzzling, on the other hand, can be the specialist species within an otherwise relatively uniform group. A good example of this is the peculiar beak of the crossbill, a pine-cone eater, compared with the pyramid-shaped beaks of the rest of

Above: The barn owl is our only member of the family Tytonidae. All our other owls belong to the family Strigidae, placed in the owl order Strigiformes.

Right: A linnet perches beside its nest of young. The very act of perching is a clue to its membership of the vast order Passeriformes, which includes nearly half the bird species of Britain and Ireland. Although the name of this order means 'perching birds', it is easy to think of non-members that also perch–falcons, pigeons, owls and kingfishers–and of a few 'awkward' passerines that rarely perch, such as swallows and skylarks.

the finch family.

The key features False clues apart, however, the majority of the features by which birds are told apart are clearly visible to the ordinary birdwatcher. For instance, the differences between the various ducks are clearly signalled–not only by the different plumage patterns but also by the detailed shape of the beak; and the same goes for the many finches. Birds of prey are distinguished from one another by their feet as well as by their colours. Bird ringers use the length and shape of the primary feathers to separate willow warblers from the similar-looking chiffchaffs, and taxonomists make wide use of the wing feathers in classification.

In certain cases taxonomists also use the skeletal anatomy, the nature of the palate, the shape of the syrinx (part of the windpipe), the layout of the intestinal loops in the gut, the length of the caecum (part of the gut) and many other internal features. Behavioural characters are sometimes used, although more attention is given to the details of physiology. In recent years, studies of blood plasma proteins, nucleic acids and egg-white proteins have joined the classical methods. In many cases the results of these exciting techniques support the established order, but in some cases they indicate that previous thinking may have been wrong.

The system unfolds If we look at the classification of birds–the class Aves–starting from the twigs of our tree, we find that there are about 8600 species of birds alive today in the world as a whole, grouped into about 170 families. Some families contain only one, or a few species, while others contain over 300.

The next level in the family tree is the order, which contains (normally) several families. Here the logic of the groupings may be more difficult for the birdwatcher, with his experience of the bird in the field, to understand. Gulls and terns, for example, which form the family Laridae, are placed by taxonomists in the order Charadriiformes. Some parts of the Charadriiformes seem to 'make sense', for its is natural to link the gulls and terns with the various wader families (oystercatchers, plovers, snipes, sandpipers and others) and with the skuas. But the same order includes the auk family, including our razorbill, guillemot and puffin, which seem superficially to be vastly different. Another, even more unlikely, fellow member is the tropical family of the lily-trotters; these would seem more sensibly located with the other long-toed birds, such as the moorhen and water rail, which are in the order Gruiformes. Nevertheless, the members of each family placed into a particular order have sufficient features in common for taxonomists to have grouped them in this way.

Most orders contain only a handful of families, though the Charadriiformes, as we have seen, is something of an exception with its 16 families. But the greatest exception of all is the last order in the list, the Passeriformes. This is an enormous order containing about half the bird species existing at present. Its gigantic range embraces wrens, birds of paradise, New World and Old World warblers, flycatchers, thrushes, pipits, tits, starlings, crows, finches, buntings and many others–altogether some 67 families.

Below: The coot is a member of the order Gruiformes. Its fellow members in Britain and Ireland are the moorhen, the water rail and the corncrake. But the order derives its name from a Continental member, the crane (*Grus grus*).

1 Black-throated diver

2 Great crested grebe

3 Storm petrel

4 Cormorant

Bird classification

Class		British Orders	
AVES	1	Gaviiformes	divers
	2	Podicipediformes	grebes
	3	Procellariiformes	petrels, shearwaters
	4	Pelecaniformes	cormorants, gannet, shag
	5	Ciconiiformes	egret, herons
	6	Anseriformes	ducks, geese, swans
	7	Accipitriformes	buzzards, eagles, harriers, hawks, kites
	8	Falconiformes	falcons
	9	Galliformes	game birds
	10	Gruiformes	coots, crakes, rails
	11	Charadriiformes	auks, gulls, skuas, terns, waders
	12	Pteroclidiformes	pallas' sandgrouse
	13	Columbiformes	pigeons
	14	Cuculiformes	cuckoos
	15	Strigiformes	owls
	16	Caprimulgiformes	nightjars
	17	Apodiformes	swifts
	18	Coraciiformes	bee-eaters, hoopoe, kingfishers, rollers
	19	Piciformes	woodpeckers, wrynecks
	20	Passeriformes	perching birds
			Total

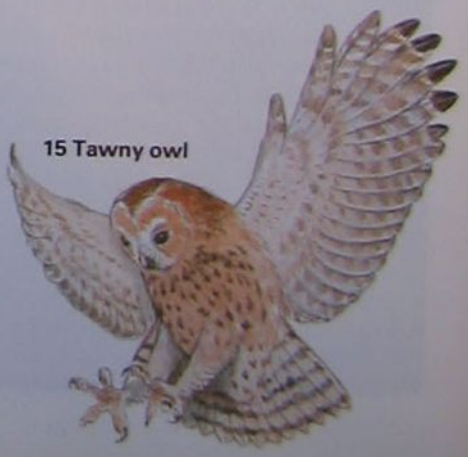
20 House sparrow

19 Green woodpecker

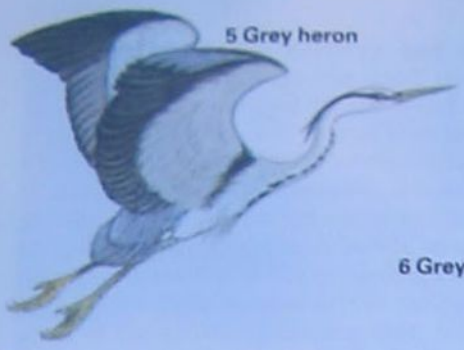
18 Kingfisher

17 Swift

16 Nightjar



15 Tawny owl



5 Grey heron

6 Greylag goose

7 Sparrowhawk

8 Kestrel

9 Pheasant

10 Moorhen

Number of British Families	Number of British Genera	Number of British Species
1	1	4
1	3	6
3	8	16
4	4	5
3	8	12
1	15	50 (approx)
2	9	19
1	1	9
2	6	9
3	9	13
11	43	120 (approx)
1	1	1
1	2	6
1	3	4
2	9	11
1	2	3
1	2	5
4	5	6
1	4	5
28	80 (approx)	240 (approx)
72	216 (approx)	544 (approx)

A breakdown of Britain's birds

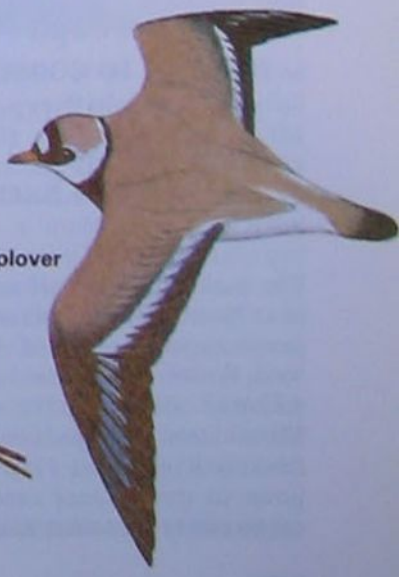
This chart shows the classification of all bird species recorded in Britain and Ireland in the past 50 years. Among these are many accidentals or vagrants: for example, the pallid, alpine, needle-tailed and little swifts are only seen as vagrants, leaving a single regular breeding species–the swift–to represent the order Apodiformes here. Altogether eight of the 20 orders are swollen by vagrants outnumbering regularly seen birds: the petrels; herons; falcons; coots, crakes and rails; cuckoos; nightjars; swifts; and the kingfisher's largely exotic order, the Coraciformes.

50 accidentals and vagrants
250 residents (approx)
240 visitors (approx)

14 Cuckoo

13 Woodpigeon

12 Pallas' sandgrouse



11 Ringed plover

THE SAND DUNES OF NEWBOROUGH WARREN

Newborough Nature Reserve is an example of a successful attempt to conserve a highly vulnerable habitat threatened by seasonal influxes of human visitors. Now they are channelled safely down to the beach where they can swim or sunbathe without harming the wildlife of this fine natural area.

The sixth largest area of sand dunes in Britain is at Newborough Warren, which forms the southernmost corner of Anglesey in north-west Wales. This dune system stretches for 4.8km (3 miles) from the southern end of the Menai Strait westwards to the wide estuary of the little River Cefni. (The name 'warren' was given to these dunes centuries ago because rabbits were kept there as a valuable source of food.) On the seaward side is Caernarvon Bay and landwards is the village of Newborough (in Welsh, Niwbwrch). From the dunes there are magnificent views east to the highest peaks of Snowdonia and south across the bay to the hills of Lleyn.

As an official borough, Newborough was truly new in the late 13th century. It was created to accommodate a Welsh community

Above: A view of the sand dunes of Newborough Warren on the Island of Anglesey. The depredations of people in this area were, at one time, very severe. Collectors came in spring to look for the eggs of harriers and short-eared owls, and they also raided the tern colonies which used to be a feature of the Warren and may one day return. In summer, too, holiday-makers wandered all over the dunes, damaging the vegetation and causing 'blow-outs' of the sand wherever the plant cover has been eroded by too much trampling. Today the area is protected as a National Nature Reserve and the increasing number of visitors enjoy themselves on the beaches without harming the wildlife.

transferred from the northern end of the Menai Straight because the land they occupied there was wanted by Edward I as the site for Beaumaris castle. At that time much of what is now Newborough's sandy warren was farming land with settlements. But the late Middle Ages was a period when storms were exceptionally frequent and in the course of time a succession of south-westerly gales blew sand off the wide beaches across hundreds of acres of farmlands. That the sand was still encroaching in Tudor times is shown by an instruction from Elizabeth I's government to the mayor of Newborough to punish anyone who took away the marram grass that was being planted to arrest the spread of sand.

These days about half the area of the warren is occupied by Forestry Commission plantations (mainly Corsican pine). The unplanted areas form a 607ha (1500-acre) National Nature Reserve cherished for its flora.

The sand dunes There could hardly be a better place than Newborough Warren to study how dunes develop. They are initiated by sand collecting round fore-shore plants such as sand sedge, saltwort, sea rocket and various oraches, and are then built higher by lyme-grass, marram and other grasses. Further inland they are stabilised by a completely closed mat of vegetation. You can also see how some of the dunes have remained as hills of loose sand and have had to be protected from the wind by planting marram or by covering them with brushwood. The outermost dunes have been wave-cut into vertical cliffs by recent gales, and on the Cefni estuary, too, great changes are in progress as sands and mudflats build up high enough for sea meadowgrass to spread widely as verdant saltings.

The ecological interest of the warren comes from the great variety of its habitats. The beaches and outer dunes experience the full force of the winds and sometimes of the waves, and are drenched with salt-laden spray which few species can tolerate. But the fixed dunes inland are a quite different, more sheltered world and most of their plants can also be found in districts far from the sea–species such as thyme, lady's-bedstraw, rest-harrow, bird's-foot trefoil, kidney vetch, brookweed, bog pimpernel and various grasses and sedges. Some dune plants, however, are strictly maritime, among them seaside centaury, sea spurge, sea holly and sand pansy.

Many of these plants flourish in the damp

Above: The beautiful sea bindweed can be seen on Llanddwyn Island (this island is cut off from the mainland only when the tide is really high). Llanddwyn has both sedimentary and volcanic rocks and hence its flora is very varied.

Right: Grass of Parnassus is a plant to look for on the inland dunes.

Below: Sandwich terns on rough grassland near the coast. Terns used to nest on Newborough but now they are only seen in winter.

sandy hollows called dune slacks, which are at their best in June when you can see the rich dark purple of northern marsh orchids along with the brick-red spikes of the early marsh orchids (which also have a distinctive flesh-coloured variety). At the same season the nearby slopes have bee orchids and the miniature fern called moonwort. In July come two helleborines: the marsh helleborine is abundant in the slacks while the drier slopes are favoured by the dune helleborine, which is known elsewhere in the British Isles only on the coast of Lancashire. Autumn brings a fine array of toadstools and other fungi.

A crucial element in the ecology of these dunes come from the fragmented shells of sea molluscs. In these lime-rich areas there are communities of calcicole plants that are typical of chalk or limestone grassland. There are not only many orchids but also such lime-lovers as fairy flax, blue fleabane, plough-man's-spikenard, carline thistle, field gentian, autumn gentian, viper's bugloss, grass of Parnassus and lesser clubmoss.

Because it is such a striking example of rapid colonization, one of the most remark-able plants of these dunes is the maritime sub-species of the round-leaved wintergreen. Until about the middle of this century it was known in Britain only in the dune slacks of Flintshire and Lancashire. Then it began to spread elsewhere and one of the places it soon reached was Newborough Warren. When the Nature Conservancy Council began to war-den these dunes in the late 1950s, this wintergreen was among the reserve's closely guarded rarities. But now it is one of the commonest plants, its round or oval, dark green, glossy leaves forming carpets on the sand, often among the great spreads of creeping willow in the slacks. Evidently the decay of millions of willow leaves every winter produces just the right humus to meet its needs.

Above: Round-leaved wintergreen blooming in a dune slack on Newborough Warren. Extremely rare on the dunes in the 1950s, this plant is today one of the area's commonest plants.

Below: You may spot the long-tailed duck in winter.

Lake plants and birds On its eastern edge the reserve has a small lake called Llyn Rhos-ddu, the margins of which are deep in aquatic vegetation, including wild iris which, in June, forms an almost uninterrupted band of yellow all around the water's edge. Floating in the shallows are pink spreads of amphibious bistort.

From a hide on the lake shore birdwatchers can observe many wintering waterfowl and in summer they may see mallard, tufted ducks, coots, moorhens and great crested and little grebes which nest there. Elsewhere on the warren other small pools have been excavated to encourage wildlife.

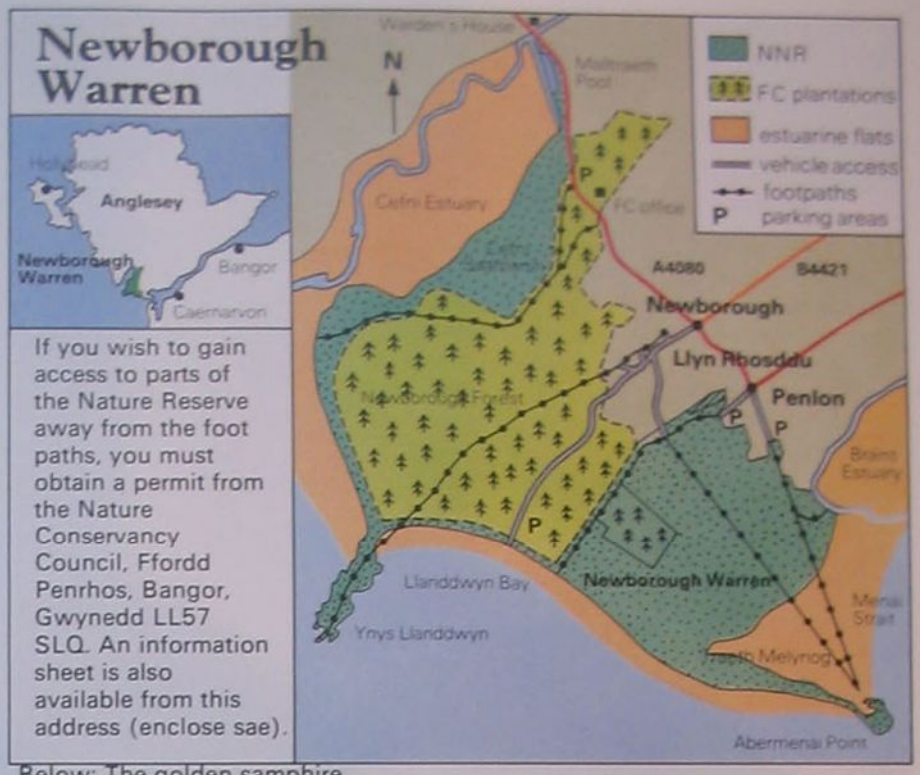
Other birds and insects The commonest breeding land birds of the reserve are prob-ably the meadow pipit and skylark, and there are smaller numbers of stonechats, whinchats and linnets. Nesting waders include a few pairs of lapwings, curlews, oystercatchers, redshanks and ringed plovers. Until recent years there were large herring gull colonies, but these have declined for unknown reasons.

These days, the warren's main birdwatch-ing interest is outside the breeding season, when the Cefni estuary is frequented by passage and wintering waders, wildfowl, gulls and terns. A pylon hide overlooks the scene from the edge of the pine plantations near the main road. Along this road at the northern tip of the reserve is Malltraeth Pool, a shallow

brackish water rich in invertebrate life and famous for its visiting waders.

The fragrant and colourful plants of this reserve are attractive to many beetles, bees, ants, hoverflies and other insects. Among several commoner grasshoppers, there is the short-winged conehead, here close to the northern extremity of its range. The most numerous butterfly may well be the common blue which, on summer days, is on the wing wherever you go among the fixed dunes. The small heath butterfly is also abundant, and in July the dark green fritillary dashes wildly by. Conspicuous among the moth caterpillars in June are the gaudily striped lackeys, which feed colonially on webs they make among twigs of hawthorn bushes. In August you may spot the green, spike-tailed larvae of the poplar hawkmoth feeding on the creeping willows.

Grazing experiments Naturalists who knew the warren over 30 years ago remember the vegetation of the fixed dunes as being much shorter than it is today, when so many tall grasses are dominant. In those days rabbits were abundant and kept the turf nibbled short. But since myxomatosis reached here in the mid-1950s, rabbits have become far fewer and this has allowed the grasses to grow–a change that could eventually lead to the development of scrub. As this would be undesirable in a reserve whose great interest is a fauna and flora of open habitats, the Nature Conservancy Council is conducting grazing experiments with Soay sheep.

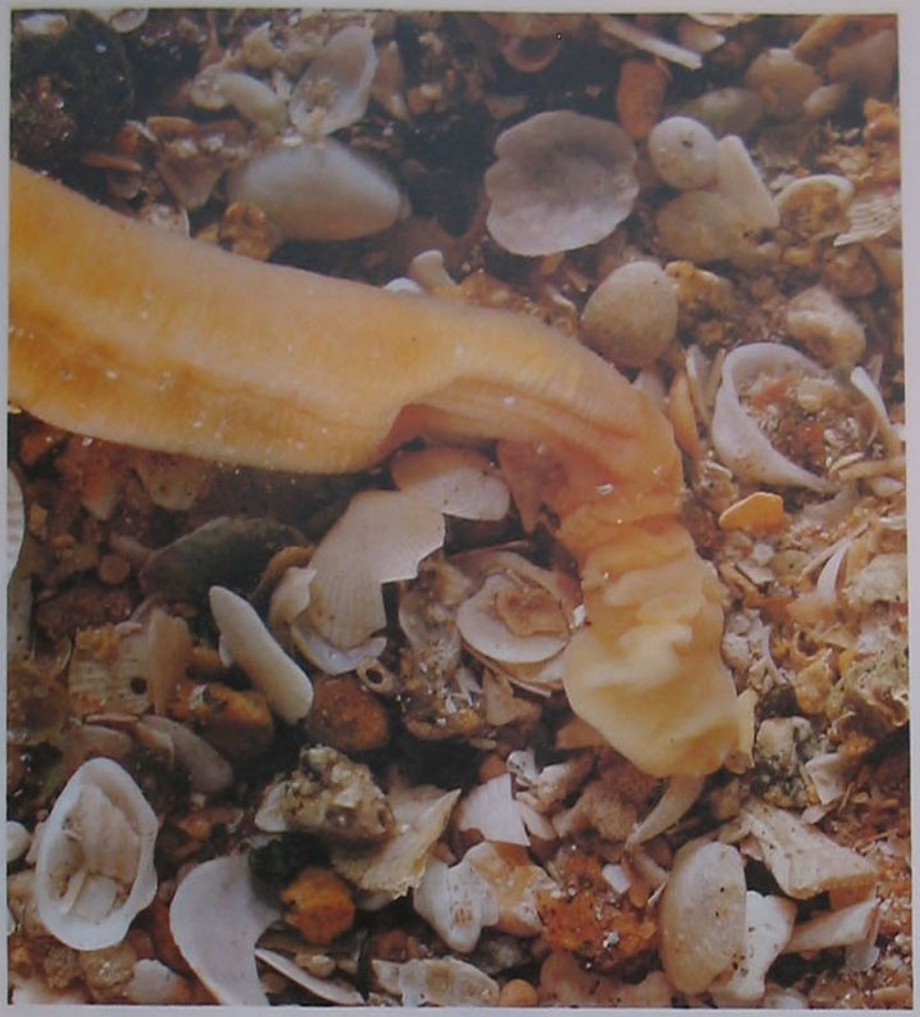


Below: The golden samphire, seen here in full flower, is one of the many plants to be found on Llanddwyn Island. One of the most striking of all is the bloody crane's-bill, which is locally abundant on the island.

Llanddwyn Island Newborough Warren is crossed from north-east to south-west by a low spine of Pre-Cambrian rocks that end in the sea to form Llanddwyn Island, which covers 24ha (60 acres) but is an island only briefly when the tide is really high. Llanddwyn's rocks are a mixture of sedimentary and volcanic materials, including some limestone, and the flora is varied in consequence. There are small cliffs whose many plants include rock sea-lavender, golden samphire, rock samphire, sea-beet, rock spurrey and sea-spleenwort. There are also several beaches with yellow horned poppy, sea-rocket, sea-milkwort, sea-sandwort and sea-bindweed.

Rocky islets close to Llanddwyn are occupied in summer by a breeding colony of cormorants; and with them are a few pairs of shags of unusual habits, for in some years they have been found nesting in mid-winter. In autumn and winter flocks of turnstones and occasionally purple sandpipers may be seen on Llanddwyn's shores.

Access to the reserve The Forestry Commission's plantations mainly occupy the central area of the warren and it is through them that three routes lead from the main road down to the shore, a distance of about 3.2km (2 miles). One of the routes is motorable and has parking, picnic and toilet facilities close to the beach. From there you can walk a mile west along the shore to Llanddwyn. In the forest there is also the Hendai ('old houses') Trail, along which visitors can learn about the plantations and forestry operations and also see the foundations of houses long buried by the sands but which have now been excavated. The National Nature Reserve has three tracks for walkers.



WORMS THAT ARE NOT SO LOWLY

Two groups of sea-bed worms–acorn worms and pterobranchs–are more advanced than other worms and even bear a distant relationship to man himself.

Above: The acorn worm *Glossobalanus sarniensis*, burrowing into shell gravel. The three main parts of its body–proboscis, collar and trunk–can all be seen clearly here. The acorn worm burrows by lengthening its proboscis and then contracting it again once it has become anchored to the substrate.

Below: The tube system of a pterobranch colony, shown here greatly magnified.

Acorn worms, and their close relatives the pterobranchs, belong to a group of animals called the hemichordates, not because they have half a spinal cord–as the name seems to suggest–but because they are very similar to the chordates. The chordates form a large group of animals, including the vertebrates, and therefore man as well, that are characterised by the fact that they have a nerve cord running along their backs.

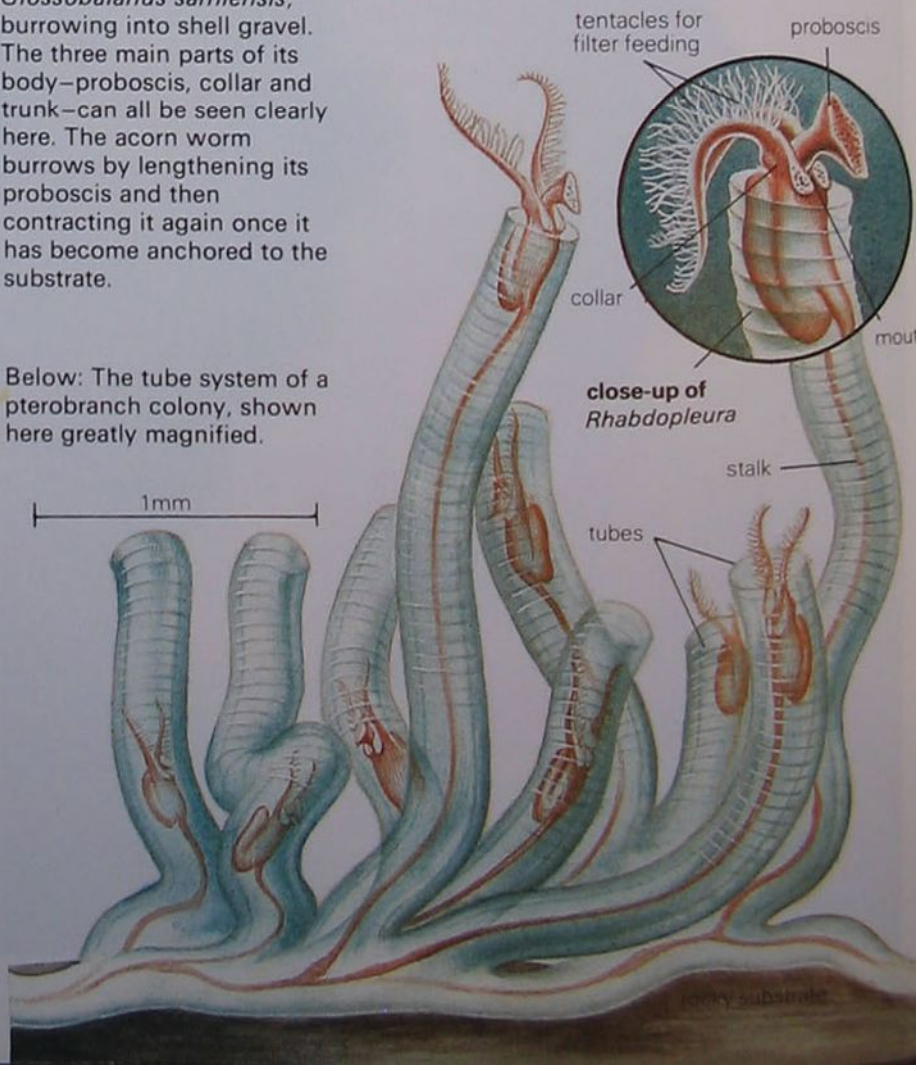
Acorn worms and pterobranchs are worm-like creatures that live on the sea-bed, the former in burrows and the latter in tubes. Pterobranchs are rarely seen because they occur in deep water. Occasionally acorn worms can be found in the intertidal zone, most often buried in mud or sand, though they also occur under stones or shells, or hidden among seaweed. Their burrows are usually U-shaped, sometimes with more than one entrance. The rear exit may be topped by a coil of waste excreted by the animal.

The sizes of acorn worms vary from species to species. *Saccoglossus cambrensis*, for example, which occurs along the Atlantic coast, grows to a length of 6cm (2½in). It burrows into clean sand or gravel from the lower shore downward. *Balanoglossus clavigerus* is longer, growing to a length of 30cm (12in), and can be found in sand, mud or clay below the shores of the English Channel and the Atlantic.

Acorn worm anatomy The body of an acorn worm is divided into three parts: a proboscis, a collar and a trunk. The front part of the trunk is perforated by a series of slits leading from the pharynx. These are the pharyngeal slits, a typical but variously modified feature of chordates–in the fishes, for example, they form the gills. Another interesting feature of the trunk is its fragility. This makes the worms difficult to collect, for they often break up on handling.

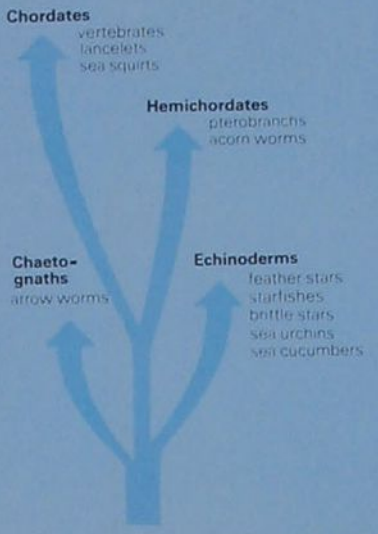
At one time, hemichordates were also thought to contain tissues equivalent to the nerve chord of a chordate, but these tissues are now known to be part of the alimentary tract. The short conical proboscis resembles an acorn–hence the animal's name. It is connected by a narrow stalk to the short

Pterobranch tubes



The animal kingdom divided

Most marine worms are fairly primitive creatures belonging to a collection of animals called the protostomes. The protostomes include such important groups as insects, molluscs and crustaceans among their number, as well as earthworms, flatworms and others. Man and other vertebrates belong to a complementary group called the deuterostomes. They contain some simpler animals as well as more advanced ones–among our more obscure deuterostome relatives, for instance, are the acorn worms and the pterobranchs.
The difference between protostomes and deuterostomes is not based on physical features but stems from the way in which the fertilised egg divides and multiplies to form the growing animal. This can be illustrated very graphically, however, if you consider what is known as the 'four-cell stage', when the egg has divided to form four cells. If one of these cells is removed and grown on by itself, then, in the case of the deuterostome, it would develop into a complete animal, whereas in the case of a protostome it would develop only into a quarter of the animal (and probably never grow past the larval stage).
The deuterostomes are comprised of several phyla of animals, the most advanced of which are the chordates–a phylum that includes man. Slightly less advanced are the hemichordates (the acorn worms and the pterobranchs).
Echinoderms, which include brittle stars, feather stars and starfishes, also belong to the deuterostomes.



cylindrical collar.

Three feeding methods In chordates lacking a backbone, and presumably also in the earliest hemichordates, the pharyngeal slits are an adaptation for feeding. The pharynx is covered with cilia (hairs) which beat to drive a current of water through a curtain of mucus stretched across the slits. The mucus sheet filters out microscopic food particles, which the animal then ingests.

This primitive feeding method is, however, found only in a few species of acorn worms. Some species ingest sediment and digest the micro-organisms therein, but most rely mainly on another method of suspension feeding, using their proboscis. Small particles of decaying organic matter or minute living organisms in the water come into contact with the proboscis, and are trapped in a layer of mucus. They are then passed back to the rear edge of the proboscis by the beating of cilia.

Particles such as grains of sand that are bigger than required are rejected, in a process involving the front edge of the collar being moved forward to cover the mouth and deflect the unwanted particles over the collar and away. Particles of acceptable size for ingestion, on the other hand, are passed into a groove leading to the mouth but may yet be rejected after tasting. The food is then passed into the mouth, often assisted by a water current entering the mouth and leaving by the pharyngeal slits.

The pharyngeal slits are important in respiration, for they are assumed to be the sites where oxygen is taken into the body and carbon dioxide is lost.

Life-cycle Acorn worms are fragile, though as compensation they are able to regenerate damaged parts of the trunk. Some species can even reproduce asexually by dividing to produce new individuals.

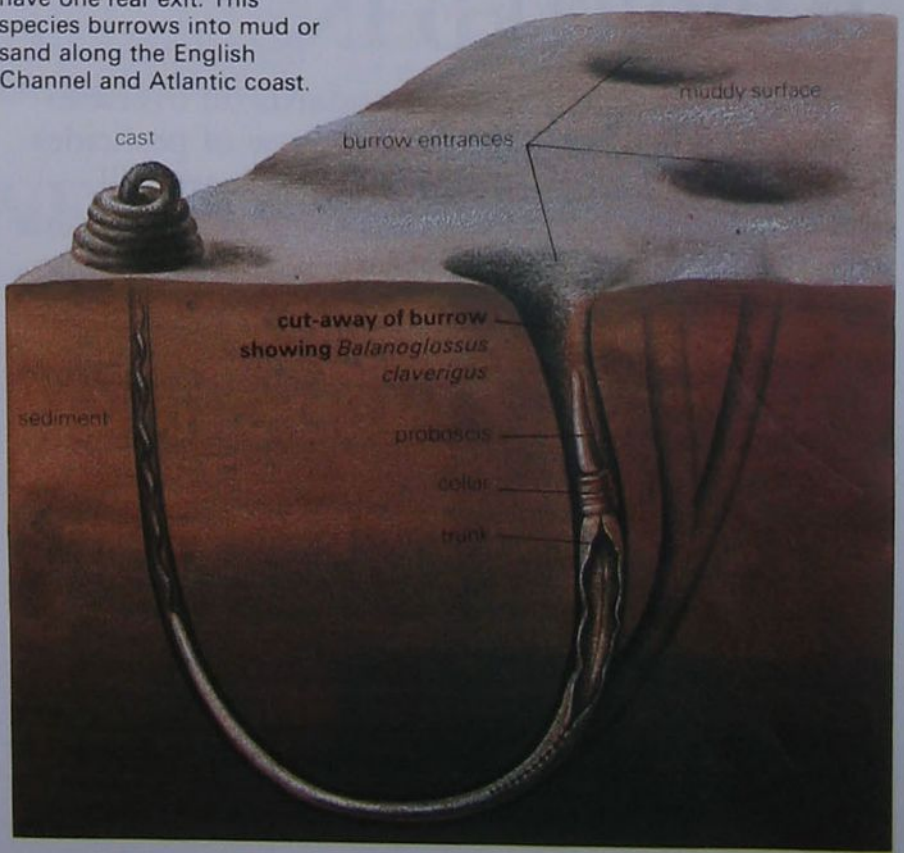
Typically, however, acorn worms reproduce sexually. The female in her burrow sheds eggs embedded in mucus into the water. This stimulates nearby males to spawn and fertilisation then takes place. The mucus then breaks up and the eggs are dispersed by currents.

In some species the acorn worms hatch out of the egg as miniature versions of the adults, but more often the egg gives rise to a planktonic larva. After a few days' drifting in the sea the larva settles on the sea-bed and develops into a worm.

Tube-dwelling relatives The acorn worm's close relatives, the pterobranchs, are small tube-dwelling creatures living in deep water. *Rhabdopleura*, for example, lives colonially in interconnected tubes, each individual being less than 1mm long. The tubes in which they live are made from a substance secreted by the proboscis. True slits seem to be absent in *Rhabdopleura*, though present in other species, and it may be that pterobranchs are more primitive than acorn worms.

Acorn worm burrows

Below: The burrowing system of *Balanoglossus claverigus*. Acorn worm burrows may possess several entrances, though they only have one rear exit. This species burrows into mud or sand along the English Channel and Atlantic coast.



ACCIDENTALLY IMPORTED INSECTS

Although general hygiene standards on overseas transport have improved (and the use of pesticides has increased), a few exotic insects are still accidentally imported here, and some even establish themselves, despite the problems of acclimatisation.

When the only means of reaching the British Isles from abroad was by sailing or rowing boat (a journey which might have taken many weeks), the chances of an insect being transported across the sea and surviving here were slender.

This century–with swift transport across the Channel, bringing man and merchandise from Europe by train and lorry, and fast aeroplanes connecting us with the remoter parts of the world–an insect's survival on the journey would seem more likely. But with modern pest control methods in other countries, greater care in packaging merchandise, and improved general hygiene standards, such as the spraying of cabins on journeys from the tropics, an insect's chances of survival are in fact reduced.

Even if the insect arrives here safely, it may never establish itself as a breeding species, as it would have to find the right kind of food and physical conditions. In addition a mate must be found if this species is to establish itself, unless the new arrival happens to be a pregnant female. It is small wonder, then, that most of our accidentally imported insects come infrequently as one-off visitors, and even fewer find conditions suitable for their survival once they arrive in Britain.

Most sightings of accidentally imported insects occur around ports, airports and large storage buildings, but there must be a number of individuals which arrive here and perish undetected.

Colorado beetles Beetles and cockroaches form the bulk of these unofficial immigrants. Of the former, the Colorado beetle is the most well known. It is an unmistakable insect, about 10-12mm long, and bright orange-red in colour with black longitudinal stripes. The hump-backed larva is about the same length as the adult, and a bright orange-red colour with three rows of black spots down each side. The egg masses, usually laid on the underside of a potato leaf, are bright yellow-orange.

Both adults and larvae feed on potato plants, which they are capable of stripping in sufficient strength. The yield of potatoes from such plants is greatly reduced and often not worth harvesting. Some farmers abroad spray their crops or inject the soil to kill the pupae, but this adds considerably to the cost of growing a potato crop.

The Colorado beetle can withstand our climate, although its original foodplant was a semi-desert member of the potato family. When potatoes were introduced with the settlers in North America, the beetle transferred its attentions to this crop and became widespread. It appears to have reached Germany by about 1877 and, just after the end of the First World War, it had effectively colonized much of Western Europe, but not Great Britain. Stray Colorado beetles usually arrive here among imported vegetables.

Foreign cockroaches Despite the extensive

Above: Colorado beetles are unwelcome visitors, as both the adults and the larvae feed on potato plants, often completely stripping a plant and leaving nothing but the stem and a nasty black excrement. Anyone suspecting they have found a Colorado beetle should report it at once to the Ministry of Agriculture.

Right: An Australian cockroach nymph. This species comes, as you may expect, from Australia and occurs around ports here.

use of modern insecticides, cockroaches still inhabit many warm places such as boiler rooms, bakehouses and insanitary kitchens. Three species (the German, the common and the American cockroaches) are established in Britain, but a number of other species are accidentally imported from time to time, mainly in fruit.

The Cuban cockroach is probably most often seen. An attractive pale green insect, it is about 2.5-3cm (1-1¼in) long, with spiny legs and thin, delicate feelers; like all cockroaches it is greatly flattened, and can easily slip into, and remain in, a bunch of bananas without being seen. The Cuban cockroach comes from the West Indies, but also occurs in Central and South America. In common with some of its relatives, which are also occasionally imported, it can survive the low temperature at which bananas are kept in transit.

The larger Madeira cockroach, now found in several banana-producing areas in the world, is another accidental visitor, and so is the much smaller short-winged cinereous cockroach from the West Indies.

Jumping immigrants Bananas also tend to harbour three species of bush-cricket, an insect related to cockroaches. The most readily recognised is the prickly bush-cricket, which comes from Cameroon in West Africa. It is a robust grasshopper-like insect, about 3.5-4.2cm (1⅓-1⅔in) long. The mottle-winged bush-cricket, which is rather longer and larger than the prickly bush-cricket, has attractively mottled wings and is also from the West Indies.

Three large, foreign grasshoppers are occasionally found in Britain. The Egyptian grasshopper, 5-8cm (2-3in) long and a sombre brown with blotched wings, is a native of the Mediterranean region, but frequently finds its way to Britain among imported vegetables. The desert locust (*Schistocerca gregaria*), with brown spotted forewings, is up to 8.5cm (3in) long, and has a conspicuous spine on its body between the forelegs; it may arrive by ship, or even fly the Channel aided by westerly winds.

The true migratory locust is the most frequent grasshopper visitor. It lacks a spine between the forelegs and is slightly smaller than the desert locust. The individuals which arrive in Britain come from Eastern Europe, in the vicinity of the Black Sea, where swarming and occasional damage to crops occurs.

Stray bees and ants One of the most spectacular of our imported insects is the huge bluish-black carpenter bee. Seen in its native south European haunts, it appears a formidable creature resembling a large bumble bee. The bees bore tunnels in wood, where they stock cells with honey and pollen to feed their larvae. Timber containing cells is sometimes imported into Britain, where the adult bee emerges.

The Pharaoh's ant is one of the smallest insects transported from overseas. It has been established for at least a century in this country, but is only able to breed in such warm and usually moist environments as canteens, hotel kitchens and hospitals. Here it tucks itself away in cracks and behind walls.

Once established, the Pharaoh's ant multiplies rapidly with an ensured supply of food, especially sweet things and almost anything edible to humans. It also feeds on mice droppings, fat droplets, dead insects, and other material which normally accumulates in unhygenic conditions.

Pest threat It would be impossible to prevent all foreign insects from being accidentally brought into Britain, but since few are likely to become pests, the problem is not a serious one. Apart from observing the legal requirements of the Ministry of Agriculture regarding the importation of plants which may harbour pests and diseases, anyone finding a strange insect in fruit, vegetables or other produce from abroad, should contact the Department of Entomology, British Museum (Natural History).

Above: The migratory locust is a frequent visitor from Eastern Europe. As well as arriving on a ship or being imported in vegetables, it also appears to be able to fly to Britain under suitable conditions.

Below: The spectacular carpenter bee. As the larval stage of this species may be protracted, carpenter bee larvae are sometimes found in timber harvested and exported. This would account for the extraordinary, and rather alarming, experience of a pianist who witnessed the appearance of this fine bee making its escape from the wood of a piano manufactured from imported timber.

Imported insects

In the last century or so swift transport across the Channel, and fast aeroplanes connecting us with the remoter parts of the world, have enabled some fairly exotic insects to arrive in Britain, among crates of bananas, other fruit, vegetables, and in timber.

1 Colorado beetle (*Leptinotarsa decemlineata*). Arrives in Britain among vegetables, not just potatoes, from N America.

2 Cuban cockroach (*Panchlora nivea*). Mainly among imported fruit, particularly the bananas coming from the West Indies.

3 Madeira cockroach (*Leucophaea maderae*). Arrives in Britain from the West Indies, mainly in crates of bananas.

4 Cinereous cockroach (*Henschoutedenia tectidoma*). Mostly with imported bananas from the West Indies.

5 Prickly bush-cricket (*Cosmoderus maculatus*). Arrives in Britain among bananas from the Cameroon.

6 Mottle-winged bush-cricket (*Jamaicana subguttata*). Arrives in Britain among bananas from the West Indies.

7 Egyptian grasshopper (*Anachridum aegyptium*). Among imported vegetables from the Mediterranean regions.

8 Migratory locust (*Locusta migratoria*). Comes in imported vegetables from Eastern Europe, particularly near the Black Sea.

9 Carpenter bee (*Xylocopa violacea*). Arrives among imported timber –and furniture– from Southern European countries.

10 Pharaoh's ant (*Monomorium pharaonis*). Arrives in imported cloth and timber from SE Asia and the tropics.

YELLOW-FLOWERED ST JOHN'S WORTS

The distinctive, bright yellow flowers of the delightfully named St John's worts make this an easily recognisable group of plants–the more so for having representatives in many different habitats and in most parts of the British Isles.

St John's worts belong to the genus *Hypericum*, a group of plants that can be recognised by the characteristic structure of their flowers. These consist of five separate yellow petals, three or five separate styles and groups of stamens called bundles or fascicles. Frequently four of the five bundles are united to form two pairs of double fascicles, with the single fascicle remaining on its own. In some non-British species all the fascicles are united in a continuous ring inside the petals.

Above: Slender St John's wort (*H. pulchrum*) is recognised by its red-tinged flower buds. Only the rare undulate-leaved St John's wort (*H. undulatum*), which is confined to the far south-west of England and Wales, shares this feature.

A feature of all St John's worts is the presence of glands containing essential oils, visible in all but the thickest leaves as translucent lines or dots. These oils are the cause of the pungent odour given off by some species. The smell often resembles curry but, in the case of stinking St John's wort, it is reminiscent of male goats.

Many species also contain a dark red substance called hypericin, located in aggregates of cells which can be seen as black (or more rarely red) dots or lines in various parts of the plant, such as the petals. Hypericin can render pale areas of skin photosensitive–a phenomenon known as hypericism–and some plants, particularly common St John's wort, have caused injury to the muzzles of grazing animals, and even death in warm regions. In northern Europe, however, this is not a common agricultural hazard, possibly because the temperature is too low and because animals graze less frequently on St John's worts.

British species There are 11 native species in Britain and two established aliens, one of which hybridises with a native. All but three of the British natives also occur in Ireland, where there is another wild species–Canadian St John's wort–which has been claimed to be native.

British St John's worts fall into easily recognisable groups based on a combination of growth habit (whether shrub or herb) and the presence and distribution of black/red glands, in addition to the flower characters. Thus the shrubs never have black glands, their stamen fascicles are separated, never united, and the petals and stamens fall before the fruits ripen. The herbs (apart from Canadian St John's wort) all have black glands somewhere on the plant, the five stamen fascicles are borne in three groups (two doubles and a single) and the petals and stamens remain on the plant while the fruit ripens. Canadian St John's wort differs in having no black glands, and the five fascicles merge to form an irregular ring.

Shrubby St John's worts To many people one of the most familiar St John's worts is rose of Sharon or Aaron's rod, a species introduced to Britain from near Istanbul in 1676. A popular garden plant, it often covers banks with its creeping stems and evergreen leaves. From mid-summer onwards it produces large, rose-like flowers with a powder-puff of stamens and five styles (the other British shrubs having three). In the wild it can be found growing in hedgerows and on railway embankments, especially in the south of the country.

Another shrubby species, this time a native, is tutsan, a plant with much smaller flowers and erect stems with heart-shaped leaves. The name tutsan comes from the French 'toute

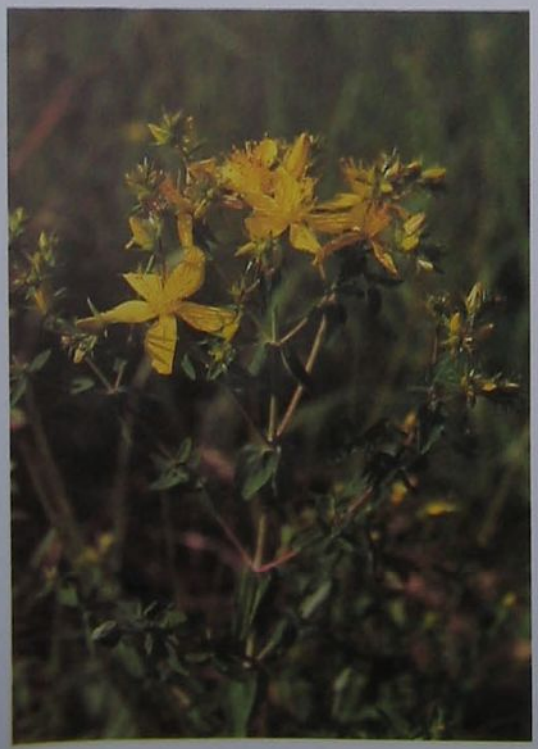
saine', meaning 'all heal' and indicates that it used to have a wide range of applications in herbal medicine.

The final shrubby species found in Britain is stinking St John's wort, an introduced plant. Both it and its hybrid with tutsan are naturalised here.

Common St John's wort Among the herbaceous species, common St John's wort is one of the most widespread. It can be distinguished from other species by looking at the stem just beneath the stalk of each leaf, where you will see pairs of raised lines dotted with black glands. The sepals are narrow and pointed, and lack glands along their margins.

Common St John's wort is variable in appearance, particularly in the width of its leaves, which on very dry habitats such as chalk are much narrower than elsewhere. In open vegetation this species tends to form large populations. Like tutsan, it was much used in herbal medicine.

Above: Tutsan (*H. androsaemum*) photographed in a Folkestone garden. Its popularity as a garden plant has allowed its natural distribution–the south and west of Britain–to increase, probably due to birds, which are said to be attracted by the shiny black, berry-like fruits.



Below left: The Latin name of common St John's wort (*H. perforatum*) indicates that the translucent gland dots in the leaves are particularly evident in this species.

Below: A flower of the introduced rose of Sharon (*H. calycinum*).

Square-stemmed species The nearest British relatives of common St John's wort have four raised lines dotted with black glands on the stems, not two. This feature gives the stem a roughly square cross-section. Among these species imperforate St John's wort looks most similar to the common species, but it can be recognised by its broader leaves (usually lacking 'perforations') and broader blunt sepals, as well as its square stem. The situation is, however, complicated by the occurrence of hybrids between the two species.

The other two square-stemmed species both grow in wetter habitats than imperforate St John's wort and have pointed sepals like those of common St John's wort. Of the two, square-stemmed St John's wort (or St Peter's wort as it is also known) is widespread, while undulate-leaved St John's wort is rarer and confined to the extreme south and west of England and Wales.

The undulate-leaved St John's wort is unusual in that its flower buds look as if they have been dipped in red wax, a feature that distinguishes it from all other British members of the genus except slender St John's wort. This latter plant is much commoner than the undulate-leaved species and has a stem with paired raised lines. It is found on heaths and open land and has no black glands on the leaves, stems or anthers, but they are present on the margins of the petals and sepals.

The red colouring on the outside of the petals is hidden when the flower expands and the bright yellow inner surface of the petals is revealed. As the red appears dark to pollinating insects they are thus encouraged to ignore the buds and confine their activities to the open flower.

Other species Bog St John's wort, which grows in damp acid mud or water up to a depth of about 50cm (20in), is unusual in that the petals do not lie flat in an open, star-shaped arrangement but are held forward to

form a tube. The filaments in each stamen fascicle are partly united and at the base of the ovary, between each fascicle, is a scale-like structure that corresponds to a sterile fascicle. These structures expand, forcing the petals apart and thus allowing an insect tongue to penetrate down the tube. Each petal has a strap-like appendage on the inside near the base which guides the tongue between the petals to the base of the ovary.

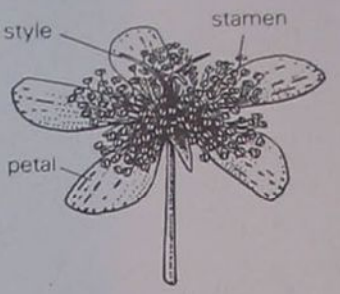
Bog St John's wort is one of only two British species with hairy stems and leaves. The other is hairy St John's wort, an erect plant which prefers well-drained habitats.

Among the other British species is the widespread trailing St John's wort, a plant of open, acid habitats, and flax-leaved St John's wort, which is confined to Wales, south-west England and the Channel Islands. Finally there is pale St John's wort, a plant of shaded places on chalk and limestone. It is absent from Scotland and Ireland.

What's in a name? It has often been stated that the word *Hypericum* comes from the Greek 'hypo' (beneath), or sometimes 'hyper' (above), and the Latin 'ericum' (heath). 'Beneath the heath', however, does not make sense in terms of any Greek species of *Hypericum*. A much more likely derivation is from 'hyper' (above) and 'eikon' (image' because the Greeks believed that at least some of the plants had powers of protection against evil spirits. Therefore they used to decorate their religious images–and also parts of the house–with bunches of these plants at times when evil spirits were said to be most active. The most important of these is Mid-summer's Eve (June 21st-22nd). This pagan celebration became, in the Christian calendar, the Feast of St John the Baptist (June 24th). Hence the common name of St John's wort.

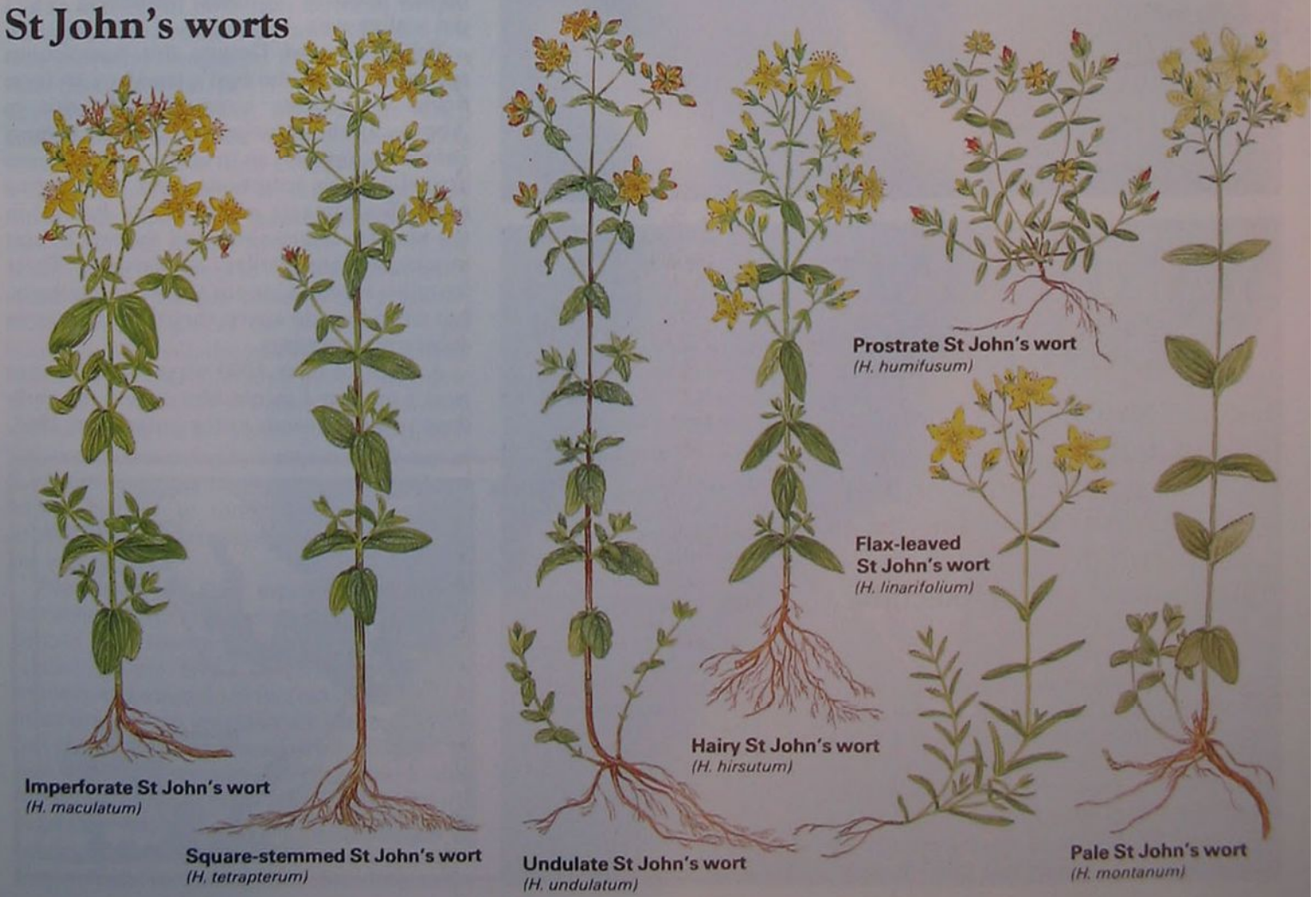
Right: Most St John's worts have star-shaped flowers in which visiting insects find pollen freely available. In bog St John's wort (*H. elodes*) the erect green sepals at the base of the flower force the petals forward to form a tube.

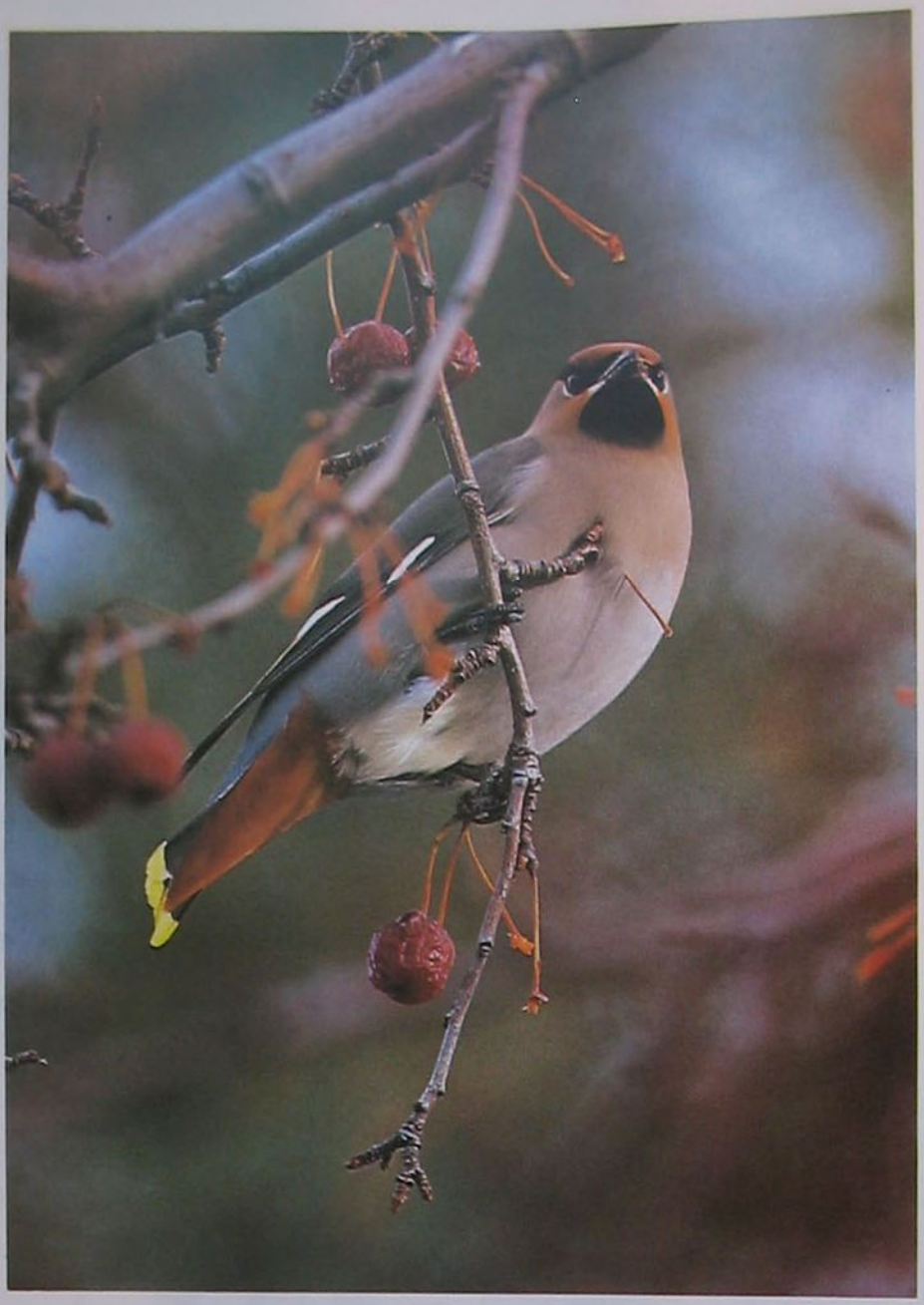
Flower structure



Above: The flower of a St John's wort consists of five separate petals, three or five styles and groups of stamens called fascicles or bundles. Frequently, four of the five fascicles are united into pairs forming two double fascicles.

St John's worts





Above: A waxwing in winter. Note the yellow tail band.

Waxwing (*Bombycilla garrulus*). Irregular winter visitor from Scandinavia and northern Russia, appearing in 'irruptions'. Length 18cm (7in). Sexes alike.

WANDERING WAXWINGS

The waxwing does not breed in Britain, for its home lies in Scandinavia and the north of Russia. It visits us only in winter, but even then its appearances are unpredictable.

One morning in early December 1970 a roadside bank in Aberdeen was suddenly transformed from brilliant scarlet to a subtle pinkish-brown. The scarlet had been an almost total cover of cotoneaster berries, upon which had settled a flock of over 400 waxwings, colourful and bizarre immigrants from Scandinavia which had just completed their crossing of the North Sea. They were busily replenishing the energy stores used on the journey by devouring the cotoneaster berries.

A handsome visitor The waxwing is a strikingly handsome bird, about the size and build of a starling. Its flight silhouette is in fact very similar to that of a starling, with long pointed wings and a short square-ended tail. If a waxwing flies low overhead, you can see that its bill is noticeably shorter than that of the commoner bird, while the tip of its tail carries a bright yellow band. Although it does not often call, the waxwing's voice can also betray its identity, for its usual note is a thin, high-pitched trill (its Russian name–'sviristel'–means 'reedpipe bird').

When seen perched or feeding, the waxwing is unmistakable. The general colour of the head, breast and belly is pinkish-brown, but the back is a darker brown. The rump and tail are grey, the latter shading into black with a conspicuous yellow tip, while the under-tail is a rich, dark chestnut. The chin is black and a black line extends round and behind the eye. The forehead is chestnut, shading into pinkish-brown on the top of the head, where the feathers are elongated into a remarkably long crest.

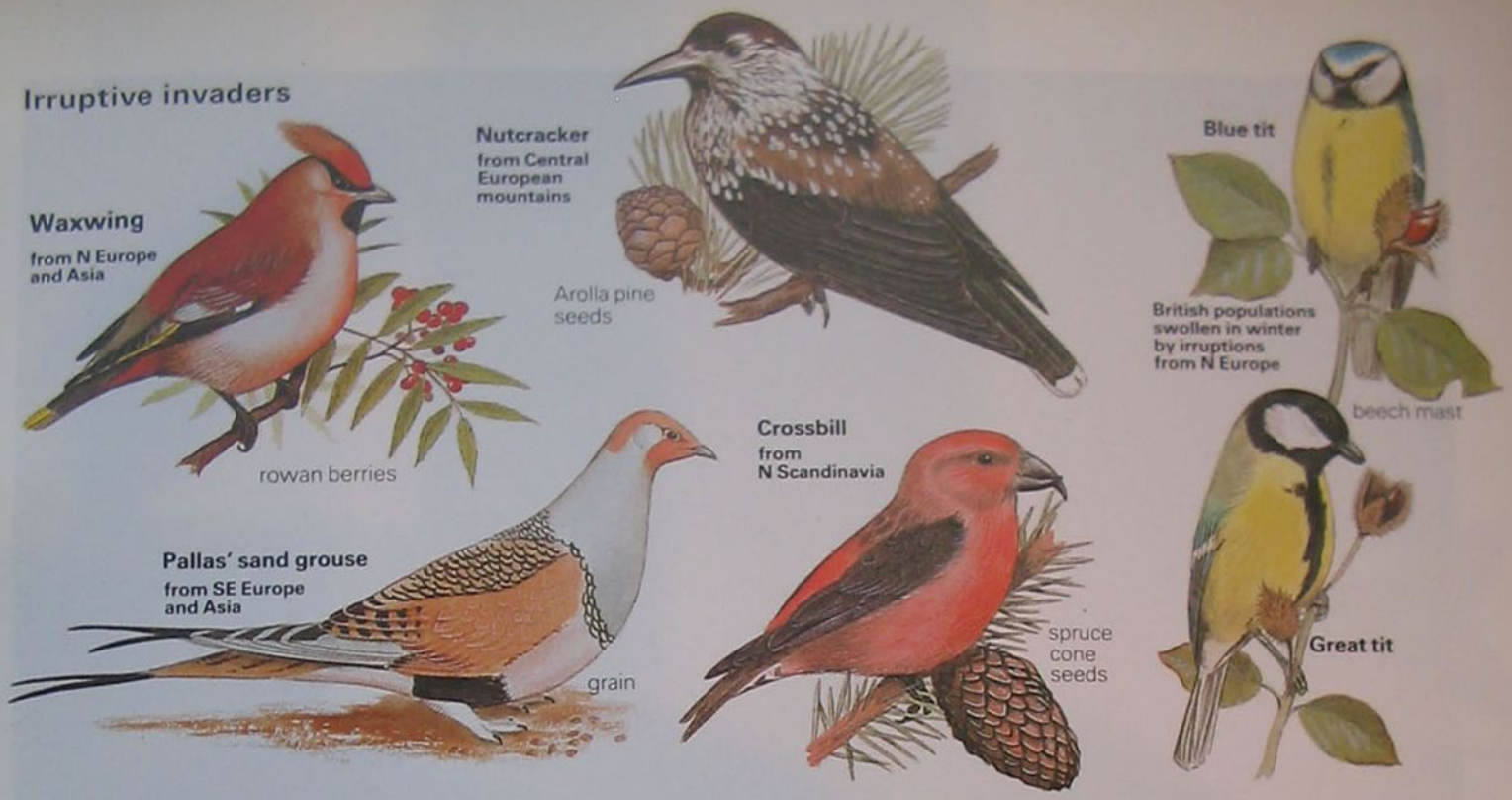
The flight feathers are mainly black but carry white markings. The bird's name is derived from the red tips to the inner flight feathers (secondaries); the webs of the feather tip are fused to the shaft, resembling bright red sealing-wax.

Britain invaded Despite this conspicuous appearance and the bird's tendency to form flocks (sometimes large, like the one in Aberdeen), the waxwing is unfamiliar to most people because it is an irregular visitor, whose arrival follows irruptions from its breeding areas (Scandinavia and northern Russia) in the manner of crossbills and the much rarer nutcracker and Pallas' sandgrouse. These irruptive species visit our shores infrequently, but when they do arrive, they tend to occur in substantial numbers.

A flock of over 1000 waxwings was seen near Louth in Lincolnshire during the early days of an invasion in the autumn of 1965.

Waxwing irruptions

When Britain plays host to these northern invaders, many other European countries–normally far south of the birds' range–also receive wandering birds. During large irruptions waxwings may range as far south as Italy, Spain and Portugal (shown on our map in a dotted line), but in most years they are able to spend the winter on their northern nesting areas. The solid lines on the map indicate the main advances of the birds in an irruption year.



Above: Besides the waxwing, other bird species arrive suddenly in Britain from time to time. When their populations have become large–this coinciding with a failure of the fruits or seeds upon which they depend–they leave their normal areas in search of food to keep them alive over winter. This is called an 'irruption'.

Below: Cotoneaster berries, and also those of rowan, hawthorn and juniper, provide the waxwing's main food in the winter.

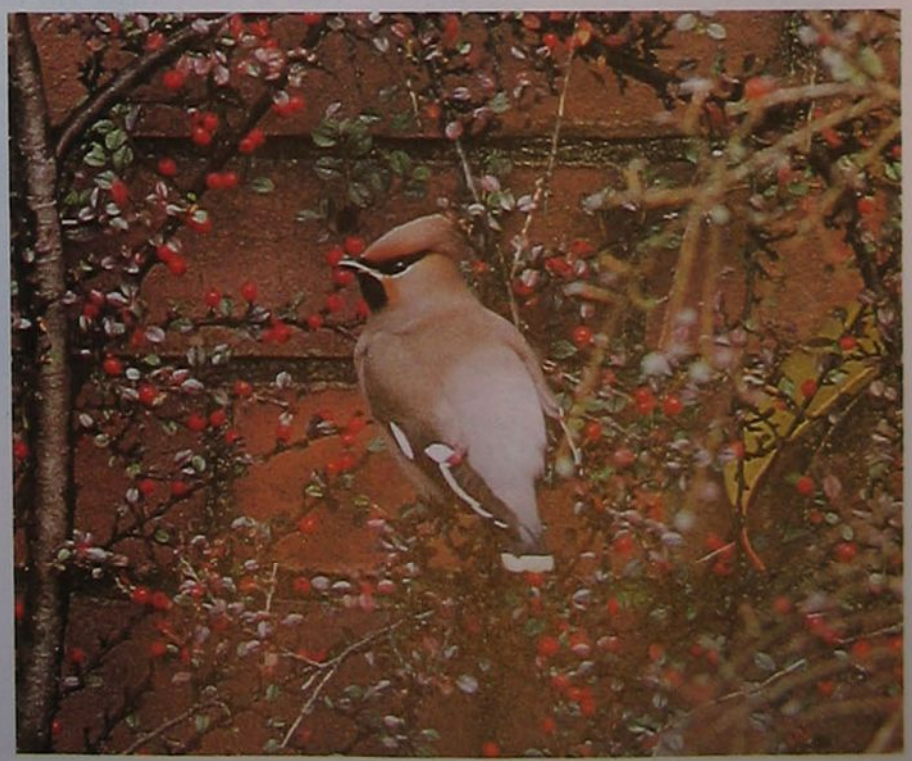
Such large flocks are typical of the early arrivals and therefore tend to occur along the east coast. As the birds move further into the country, these large flocks break up so that later in the winter, and the further west one goes, the smaller the flocks tend to become. Nevertheless, flocks of a hundred or more do occur occasionally in Ireland.

The number of birds that arrive in Britain during an invasion can vary widely from a few tens to several thousands. Equally variable is their time of arrival. In 1965 the earliest birds appeared in September, while in the much smaller invasion of the 1956-7 winter waxwings were not seen until February.

Once an invasion of Britain occurs, they move from their initial landing places on the east coast and spread to other parts of the country, but the extent to which more westerly areas receive visitors depends to a certain extent on the size of the irruption. When numbers are small, the waxwings may remain near the east coast, but after a large immigration, as in the 1965-6 winter, the westward spread during the early part of the invasion is followed in the spring by a return to the east of the country as the birds that have survived our winter prepare to return to their breeding grounds. Most waxwings have left Britain by the end of April.

Population and food supplies This unpredictability over the waxwing's arrival in Britain and southern Europe is ultimately related to the bird's diet. In spring and summer waxwings do in fact eat insects, but at other times of the year they are vegetarians. In fact they are among the relatively few species that can, if necessary, survive on a diet consisting solely of plant material. Within the vegetable realm, however, waxwings prefer berries and it is this specialisation which forces them to vacate their breeding areas periodically.

Most fruiting trees do not produce large crops every year, rather they crop heavily every second year, but even this heavy crop can be quite variable. In the vicinity of the breeding areas rowan, hawthorn and juniper are the waxwing's main autumn and winter foods. If a series of good breeding seasons coincides with reasonable winter berry crops, the waxwing breeding population increases over successive years and may extend the breeding area southwards. Once a high population level has been attained, a failure of the berry crop will force these birds to emigrate in search of sufficient berries to survive the winter.



STILL-WATER BITTERLING

Until a few years ago a bitterling could only be seen in aquariums in Britain, for it is not native here. Now however, this fish, although uncommon, occurs in many British waters.

Superficially, the bitterling is shaped like a crucian carp, the head being relatively small, the body deep, and the dorsal fin moderately long and high. Its scales are rather large with between 34 and 40 rows between the head and the tail fin. It is, however, unique among our carp family fishes in that its lateral line–the series of open pores leading to sensory cells under the scales–has openings on only the first five or six scales from the head. This possibly gives a clue to its relationships within the carp family, for other European and Asiatic fishes have similar short lateral lines, and similar breeding biology.

Breeding dress Outside the breeding season the bitterling is a very modestly coloured fish, the back being grey-green, and the sides and belly bright silver, while along the mid-side from the level of the dorsal fin to the root of the tail there is a shining grey-green stripe. The dorsal fin is dark greenish, but the other fins are a delicate yellowish brown. In the breeding season, however, the male in particular is transformed. His back becomes distinctly green, the sides iridescent and the stripe along the side steel blue with rainbow tinges showing at the edges as the fish turns. The dorsal and anal fins are reddish with a black edge, and the throat and belly become dull red. Large white spawning tubercles develop on the front of the head.

The female bitterling is less brilliantly coloured, but nevertheless her coloration is brighter when spawning. The most striking change in the female is that she has a long–up to 5cm (2in)–coral pink egg-laying tube which projects from the front of her anal fin.

Undoubtedly it was the brilliant coloration of the male fish, and the quiet beauty of the female, that made them popular as cold water aquarium fishes from the 1920s onwards. At that time, it was possible to purchase them from a number of dealers in pond-life, most of whom obtained much of their stock from mainland Europe. Inevitably, fishes escaped when garden ponds flooded, and aquarium fish were released into ponds and rivers when their owners tired of them.

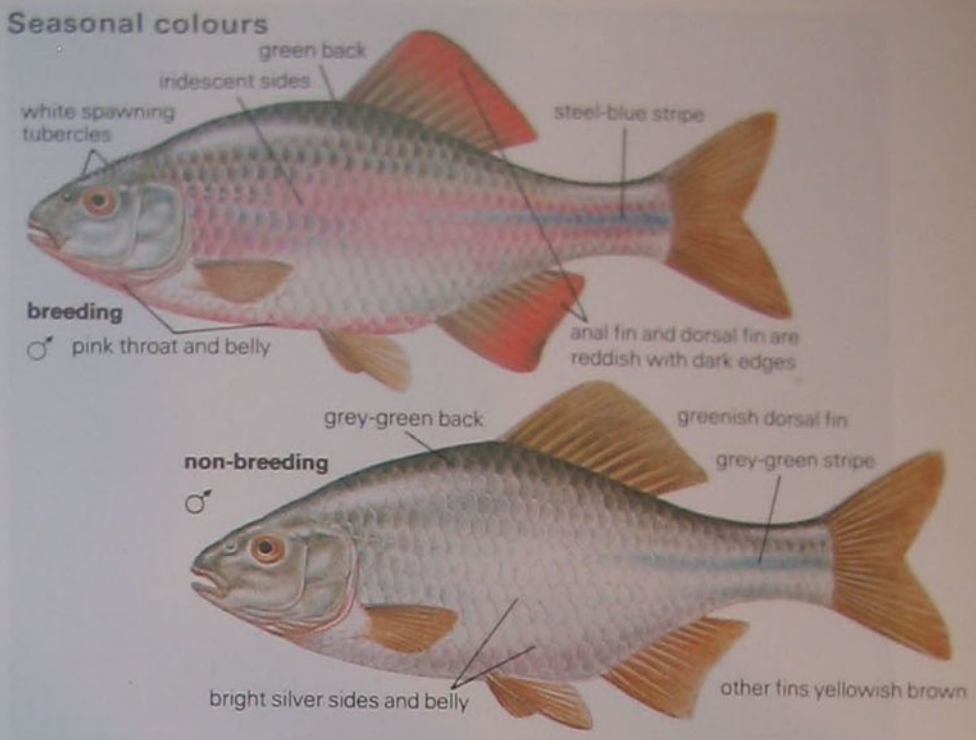
Escapee population The earliest established

Above: The bitterling (*Rhodeus sericeus*) is a member of the carp family and, like all members of that family, has a scaly body but no scales on the head. Neither the single dorsal fin nor any of the other fins bear spines. Its jaws are toothless but all carps have a pair of curved bones, set in the back of the throat, on which there are fixed numbers of broad teeth which crush their food against a pad in the roof of the pharynx. These are called the pharyngeal teeth and the bitterling has five strong flattened teeth on each side. Now that this fish has been introduced to British waters, there is always the possibility that anyone pond-dipping for water life, or an angler, will come across new localities, for it has proved to be a very successful fish in English fresh waters and will continue to spread, with man's help.

populations of bitterling in Britain were found around St Helens in Lancashire before World War II, in two or three waters known as flashes. Then, soon after the war, they were reported from about a dozen waters in the area. Local naturalists, and possibly children, helped their spread, and anglers were reported to have used them as live bait, releasing some unharmed in other waters. Soon their range increased to parts of Cheshire. Subsequently they have been found in several Midlands canals and lakes, including one at Stoke-on-Trent, and in Hertfordshire and Surrey in southern England.

The bitterling is not a large fish – it grows to 9cm (3½in) at the most – and it does not appear to be a serious predator on our native fauna, nor a competitor with our native fishes. Its food is comprised of a mixture of plants (mainly algae growing on other plants, but also the new growths of aquatic plants), small crustaceans and insect larvae.

Swan mussel nurseries Probably the most fascinating feature of the bitterling is its interesting and complicated breeding behaviour. For successful reproduction it depends on the presence of swan mussels (*Anodonta* spp.). The long egg-laying tube developed by the female bitterling at the beginning of the spawning season in April and May allows her to lay her eggs inside the valve of the mussel, on its gills. But before egg-laying the fish conditions the mussel to her presence by nudging it with her snout, which ensures that the mussel does not react to the insertion of the ovipositor by clamping shut on the female fish. After the first eggs are laid the male bitterling comes close to the mussel and ejects a small quantity of sperm, which is pumped into the mussel's gills as it respires; the eggs are thus fertilised. Usually only two or three eggs are laid at a time, and spawning is repeated by the pair of fish until all the female's 40-100 eggs are laid. Several mussels are used as nurseries.



Above: Outside the breeding season the bitterling is not particularly bright in colour, but in spring the male is transformed, developing iridescent sides and pink/red dorsal and anal fins, throat and belly.

Below: The bitterling prefers to live in still waters, especially among dense weeds in the shallows at the edges of ponds and lakes, in the backwaters of rivers and in slow-flowing rivers (although it avoids strong currents).

The eggs are about 3mm in diameter – large eggs for such a small fish – and remain wedged in the mussel's gills for up to four weeks, although in warm seasons they may hatch in 21 days. They leave the mussel within two or three days of hatching, once their supply of egg yolk is used up.

This fascinating use of another animal to act as a nurse to the eggs is clearly very successful. Compared with many of their relatives of similar size, the bitterlings lay very few eggs, in itself evidence that their system works well. The eggs, of course, are placed in a highly suitable position to develop in the oxygen-rich surroundings of the mussel's breathing current, an important consideration in the shallow, still waters in which they live. Moreover, if there is a drought, or conditions in the water become unfavourable for its own survival, the mussel closes its shell, or moves through the muddy lake or canal bottom to a more suitable area, taking the bitterling's eggs with it. In addition, the eggs and early fry are well protected from predators inside the mussel's hard valves at the bottom of the lake or pond.

The only price the bitterling has to pay for its use of the mussel is that when it comes close to the mollusc it frequently becomes host to the minute, parasitic, glochidium larvae of the mussel. The larva, attached by a long sticky thread, is taken in tow by the fish until its toothed shells take hold of a fin, when they clamp shut, later to become encysted in the fish's skin. This causes little damage to the fish but aids in the dispersal of the swan mussel, a classic case of one good turn deserving another.

DRY FRUITS AND THEIR DISPERSAL

The word 'fruit' usually conjures up an image of something edible and succulent–a fleshy fruit. Yet much more common are the dry fruits, such as acorns or the parachute-like fruits of dandelion, all adaptations to ensure dispersal of the seeds.

Fruits fall quite naturally into two general categories: fleshy fruits and dry fruits. The fleshy fruits have become specially adapted to be eaten by animals as a means of ensuring that the seeds inside are dispersed. They can be divided into different types according to their structure. There are the berries, such as mistletoe and nightshade berries, drupes, which includes plums, cherries and sloes, and false fruits, such as strawberries and apples.

The dry fruits, on the other hand, form a much larger group than the fleshy fruits and are much more versatile in terms of seed-dispersal strategies.

Edible nuts One group of dry fruits has evolved a similar strategy to the one used by fleshy fruits. These are the nuts, a group that includes acorns and hazel nuts. However, instead of relying on the seeds passing through the animal undigested and being excreted, nuts rely on the fact that, although most are eaten and thus destroyed, some always survive. For example the squirrel, making stores of nuts for the winter, frequently forgets the locations of some of them: those nuts have been successfully dispersed.

This may seem a wasteful strategy yet only one out of the hundreds of thousands of acorns produced in the life of an oak tree needs to grow and reach maturity for the population of the species to be maintained.

Many species have fruits that are very similar to a nut, but much smaller. They are often called nutlets and they function in much the same way as a nut. Some of these smaller fruits may be eaten and pass through an animal undigested, like the seed of a fleshy fruit.

Some so-called nuts are technically quite different structures. The almond, for example, is the centre of a drupe and is equivalent to a plum stone. A horse chestnut is not a nut but a large, hard-coated seed, though the sweet chestnut is a nut. The spiny structure enclosing the sweet chestnut on the tree is formed from modified bracts surrounding the flowers, as are acorn cups and the cases containing beech nuts.

Clingers-on Many plants use animals to disperse the fruit–not by the fruit being eaten but by its hitching a ride clinging to fur or feathers.

With no potential food to attract an animal, such plants have to rely on chance encounters which are relatively scarce and brief, so an effective method of attachment is required. Species such as cleavers, enchanter's nightshade, hedge parsley and spotted medick all have fruits bearing numerous hooks, which function in the same manner as the hooks on a man-made 'Velcro' fastener.

Hound's-tongue has spiny fruits, each spine having microscopically small, curved hooks at the tip which are so sharp that, when magnified, they make the tip of a needle look blunt by comparison. Lesser burdock adopts

Above: A stand of greater reedmace, or bulrush, in the autumn when its flower heads have ripened into masses of fruits, each of which is equipped with tufts of hairs that will allow the fruit to be carried away on the wind.

Right: This close-up view of the fruits of wood avens shows how they are equipped with long, hooked spines with which they latch on to a passing animal and 'hitch a ride' until they fall off some distance away.

a slightly different strategy as the entire head of hooked fruits becomes detached from the parent plant, later to break up and spread the seeds.

Catching the wind A great number of plants have dry fruits that are specially adapted to be dispersed by the wind. Small size alone may be enough for the fruit to catch a free ride but, if the individual seed rather than the whole fruit is being dispersed, then the structure can be smaller still.

Plants such as orchids have adopted this strategy, their fruits opening to release the seeds. The method of opening differs from one species to another. A common method is to have small pores in the fruit so the wind shakes out a few seeds at a time.

Wings and parachutes More obvious adaptations for wind dispersal are the wings and parachutes employed by many species. Maples, silver birch, ash and Scots pine all have winged fruits. Parachutes are very common among members of the daisy family. One species, Oxford ragwort, which was introduced to Britain from its native Sicily, escaped from cultivation at the Oxford Botanic Garden and, aided by its parachute fruits, has now spread to much of the British Isles.

Among native members of the daisy family, perhaps the most spectacular fruits are those of goat's-beard, named after the tufts of silky hairs that make up the parachute. The thistles belong to the same family. Many of their fruits seem to have lost their original function: on an autumn day clouds of thistledown can be seen drifting across a meadow yet, frequently, none of the parachutes bears seeds. In the case of the Scots thistle, the fruits are probably dispersed by birds such as goldfinches, which avidly feed on them.

Floating fruits Water provides an efficient means of dispersing fruits, and many plants have been quick to take advantage of it. The large green fruits of the yellow water-lily –known as brandy bottles because of both their shape and their alcoholic aroma–are equipped with air spaces to make them buoyant. They are capable of floating for some distance. Pondweeds also have floating

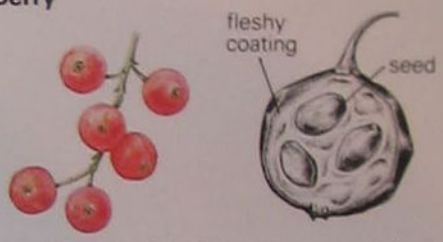
Above: Like many members of the daisy family, the spear thistle produces parachute-like fruits that are light enough to be carried great distances on the wind. The seed itself is the small, pale brown structure at the centre of the long silver plumes.

Right: The four major categories of fleshy fruit differ according to their structure.

Below: Nuts, such as these hazel nuts, represent a particular adaptation. They all have large food reserves which are needed to supply the developing seedlings with nutrients, enabling them to grow tall enough to overshadow the competition. Yet the presence of such large food stores makes the nuts much heavier than any other type of dry fruit; certainly far too heavy for them to be distributed by wind, water or any other way. Without the assistance of animals, nuts would have little chance of being dispersed.

Fleshy fruit types

Berry

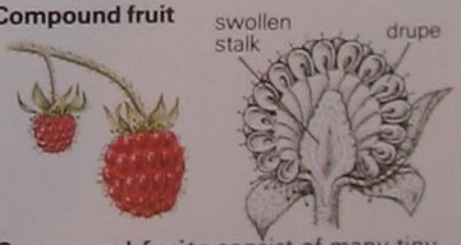


Berries consist of one or more seeds embedded in a fleshy coating. Example: redcurrant.

Drupe

Drupes consist of a seed encased in a hard shell, itself surrounded by a fleshy coating. Example: sloe.

Compound fruit



Compound fruits consist of many tiny drupes arranged around a swollen stalk. Example: raspberry.

False fruit

False fruits consist of fruits embedded in a structure such as the flower's receptacle. Example: strawberry.

Left: The winged fruits borne by many trees are one of the most familiar adaptations for dispersal by wind. The fruit of the introduced sycamore (shown here) and our native field maple both consist of pairs of seeds each enclosed within a wing. The two wings have slightly different shapes causing the fruit to spin as it falls from the tree. This slows its fall and allows the wind to carry it some distance from the parent plant.

Above: The fruit of a pansy is a capsule which opens before the seeds are ripe and then closes again to squirt out the mature seeds.

Below: A poppy's capsule contains small openings near the top, through which its thousands of tiny seeds are released–a few at a time–by the action of the wind.

fruits which disperse in freshwater ponds and streams.

A great many plants growing near the sea are dispersed by water, including sea radish and sea kale, both plants with corky fruits that can survive for days or even weeks and still remain buoyant. It is interesting to note that the first flowering plants to colonize the new volcanic island of Surtsey off Iceland included sea sandwort and a close relative of the sea rocket. In both cases the seeds would have arrived by sea.

Self-dispersal Rather than rely upon the vagaries of wind and water to disperse their seeds, some plants do the job themselves. A notable example is the pea family, many of whose members have explosive pods. The tree lupin, for instance, which was introduced to this country from California, rapidly spreads over shingle banks by firing its seeds on to uncolonized ground.

Two fairly common weeds of gardens can be a source of great annoyance to the gardener. Both hairy bitter-cress and yellow sorrel have explosive dispersal mechanisms, and any attempt to remove either plant results in a shower of tiny seeds being sprayed over the garden.

Buried alive A number of adaptations of fruits are concerned not just with dispersal but also with the subsequent establishment of the seedling by ensuring that it starts life in a favourable environment. A particularly interesting example is provided by stork's-bills. This is a group of plants very closely related to crane's-bills and both have similar-looking fruits shaped like a long narrow beak–hence their common names. But the two fruits have quite different strategies. The crane's-bill fruit splits from its base to its tip, in doing so flinging out the seeds and dispersing them.

The stork's-bill has a quite different technique. The beak splits in the same way but the seed is not flung out. Instead, the seed, which is attached to a corkscrew-shaped tail formed from part of the 'beak', falls to the ground (or it may be carried away on an animal and then fall to the ground). Once on the ground any changes in the humidity of the air causes the tail attached to the seed to twist. But the presence of hairs on the seed means that the seed can be twisted in only one direction, not the other. The result is that the seed and its corkscrew-tail progress along the ground until they encounter a crevice. The same twisting motion causes the seed to become buried in the crevice, where it germinates.

A few species seem to have an apparently pointless adaptation in which the fruits are immediately buried in the ground or a crevice, so preventing their dispersal. However, from the point of view of providing the seedling with the right environment the strategy makes sense. Take, for example, the case of the ivy-leaved toadflax. This plant inhabits the crevices of rocks and walls. After fertilisation it pushes its fruits into a crevice where some of the seeds remain to germinate. This provides them with a much better environment in which to grow than they would have if they were left on the rock or allowed to fall to the ground to compete with other plants.

A similar adaptation is shown by the subterranean clover, a rather rare plant of sandy and gravelly soils in southern Britain. After fertilisation the whole flower head is pushed into the ground, where its modified sepals act as anchors, preventing the fruit from being pulled back out.

Dispersal mechanisms

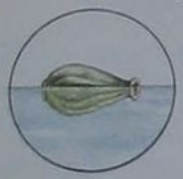
Ingestion

Right: Most fleshy fruits, and several dry fruits such as nuts, are adaptations for being eaten by animals. In fleshy fruits the seeds are voided, while nuts rely on the animal gathering (and thus dispersing) them but subsequently forgetting their location.

Mistletoe
(Viscum album)

Beech
(Fagus sylvatica)

Water dispersal



Yellow water-lily
(Nuphar lutea)

Sea kale
(Crambe maritima)

Left: Many plants growing close to water—whether fresh or salt—take advantage of this means of seed dispersal. Such seeds, however, have to be buoyant and are often equipped with air pockets for the purpose. Others have a specially light, corky texture.

Self-dispersal

Right: Several plants, including most members of the pea family, rely on an explosive mechanism to fling their seeds sometimes several yards from the parent plant, thus avoiding the vagaries of wind, water and animals.

Indian balsam
(Impatiens glandulifera)

Self-burial

Sea stork's-bill
(Erodium maritimum)

Left: Burial of the seeds is a technique favoured by some plants, especially those that grow in crevices. The plant thus sacrifices long-distance dispersal for the security of at least some of its seeds germinating.

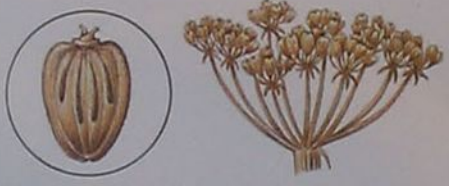
Wind dispersal

Right: Some plants rely on the wind shaking a few seeds at a time out of a capsule. Being extremely tiny, the seeds are then borne away, the distance and direction depending on the wind.

Harebell
(Campanula rotundifolia)

Common poppy
(Papaver rhoeas)

Common ash
(Fraxinus excelsior)



Hogweed
(Heracleum sphondylium)

Left: Another method of utilising the wind is to produce fruits that consist solely of a lightweight seed and a wing to carry it away from the parent plant. This method of dispersal is fairly common among trees.

Goat's-beard
(Tragopogon pratensis)

Right: The other common strategy for harnessing the wind is to equip the seed with a 'parachute' that can catch the wind and carry the seed for perhaps several miles before settling down. Other plants have developed long feathery plumes that perform a similar function.

Traveller's joy
(Clematis vitalba)

Animal dispersal

Herb Bennet
(Geum urbanum)

Nodding bur-marigold
(Bidens tripartita)

Left: As well as dispersing seeds by feeding or storing, animals can also perform the same function unwittingly by carrying them on their fur or feathers. Fruits that are dispersed in this manner have developed hooks or barbs as a quick, effective method of attachment to the animal.

Above: The puss moth caterpillar actively defends itself when camouflage fails. When alarmed it pulls in its head and creates a fearsome 'face'–an effect reinforced by the two red 'whips' that protrude from the tail end.

CATERPILLARS: A PICTURE OF DIVERSITY

A caterpillar's principal task is to accumulate food reserves which can then be used by the adult butterfly or moth. The dangers to which this task exposes caterpillars are so great that their appearance is influenced considerably by the need to protect themselves.

Below: For predators, the garden tiger moth caterpillar poses a serious threat, for as well as being poisonous it possesses irritant hairs.

In the strict sense a caterpillar is the name given to the larval stage of butterflies and moths–the only real exception being the caterpillar-like larvae of some sawflies.

Caterpillars have an external body covering or cuticle which only stretches within certain limits. In order to grow, therefore, a caterpillar has to shed its old cuticle at intervals. This is called moulting and involves the caterpillar inflating itself by swallowing air until the old cuticle splits and the caterpillar, in its new skin, can wriggle out. The new cuticle revealed is soft and has to be kept inflated until hardened by a chemical process. Caterpillars may have between three and nine instars (stages between each moult), but the normal

number is four or five.

Caterpillar function A caterpillar's principal task is to provide building material for the adult moth or butterfly by accumulating food reserves–the adult stages of some species of moths (the emperor moth, for instance) cannot feed at all. Since feeding exposes caterpillars to the dangers of predation it is extremely important that they adopt some form of protection. This protection factor has had a considerable influence on the appearance of caterpillars, so much so that it is possible to categorise caterpillar types–and consequently their appearance–according to their defence tactics.

Leaf-miners and case-bearers The simplest caterpillars are those of the small, so-called micro-moths. Simple, whitish in colour, and grub-like, many of these caterpillars gain protection during feeding by mining inside the leaves, stems or branches of trees. The most common example of a leaf-miner is the caterpillar of the blackberry leaf-miner, whose early instars mine blackberry leaves. The two main groups of moth caterpillars which bore into tree branches and stems, however, are those of the Cossidae, represented in Britain by the goat moth and leopard moth, and the clearwings.

Another mode of life widespread among the smaller moths is that of the caterpillar which lives inside a case. Like the larvae of caddisflies, these caterpillars construct a protective case around themselves with only their heads and legs protruding. The families Coleophoridae and Psychidae, sometimes called case-moths or bagworms, are good examples of these species. The cases are often made entirely of silk, but may be strengthened with pieces of leaf.

Many grass-feeding caterpillars bind together blades of grass to form tubes. This is widespread among Crambidae or grass moths, but perhaps more familiar as grass-tube dwellers are the caterpillars of our skipper butterflies.

The next logical step in caterpillar protection is to make a silken web over part of the leaf or plant on which they feed. The small magpie moth, for instance, spins together the edges of nettle leaves, keeping a humid microclimate around itself. You may also find the conspicuous webs of the early instar small tortoiseshell and peacock butterfly caterpillars on nettles. Along roadside verges and in orchards the enormous silken webs of the small tortoiseshell moth sometimes occur on blackthorn or apple. These webs are particularly effective in keeping the small caterpillars safe from birds, although parasitoids take a heavy toll.

Above: Caterpillars that feed in exposed places, such as on leaves, must conceal their tube-like shape if they are to avoid the attention of birds. The eyed hawk-moth caterpillar, in common with many other such caterpillars, achieves this by using a subtle blend of colours–known as countershading–which disguise its shape.

Below: One entire family of moths, the geometers, disguise their shape by resembling twigs. Also known as looper caterpillars, they are excellent stick mimics, even down to the bark and protruding buds. The uncanny resemblance can be seen in this September thorn moth caterpillar.

Colour camouflage By far the greatest number of caterpillars feed openly on the leaves of growing plants or trees. Many birds, such as blue tits, specialise in eating caterpillars at certain times of the year so the caterpillars' main problem is to avoid becoming a meal for hungry birds. Although most of them feed under cover of dark, when birds cannot see them moving around, they still need to conceal themselves during the daytime. They have done this by evolving a great variety of shapes and colours.

One of the commonest ways in which caterpillars conceal themselves is to merge in

The protection racket

The ultimate in caterpillar protection is the evolution of a bodyguard system. This is adopted by the caterpillars of Lycaenid ('blue') butterflies which are guarded by ants. Although admirably protected by their colour pattern, the caterpillars of most of our blue and hairstreak butterflies have a special gland which produces a sweet liquid. This fluid appears to contain a compound that, like a scent, attracts ants from a distance, and then provides them with food. The presence of ants effectively deters would-be predators such as large beetles, and sometimes even insect-eating birds as well.

Above: The caterpillar of the lobster moth assumes a weird lobster-like appearance when alarmed, which successfully frightens off potential predators.

with their foodplant. This is what is called camouflage, in its broadest sense. Grass-feeding species, such as the brown butterfly caterpillars, are invariably adorned with longitudinal stripes in shades of green, which enable them to merge with the linear grass blades when not feeding. A similar pattern is adopted by such caterpillars as the pine beauty and swallow prominent, which rest by day on twigs and leaves.

Caterpillars that feed on the leaves of trees often rest on the upper surface. The great problem faced by these species is how to conceal their tube-like shape. Most caterpillars of this type use a very subtle blend of colours, known as counter-shading; by having pale colours on the lower parts of their bodies and legs they manage to cancel out the effect of shadow. This camouflage method is so successful that even large caterpillars, such as those of the poplar hawk-moth, can be difficult to see.

An entire family of moths, the geometers, do not try to disguise their simple tube-shape just by colour. Instead they closely resemble twigs. Equally effective in avoiding predators are the caterpillars that mimic bird-droppings. The best examples of these are the young caterpillars of the alder moth and swallowtail butterfly. Both these species undergo a dramatic transformation in the later stages to become gaudy black and yellow caterpillars.

Hairy protection All the free-living, camouflaged caterpillars have one great restriction. They must not move during the day –most birds have extremely sharp eyes and can spot the smallest movement. This means that the majority of these caterpillars can feed safely only at night or in the late evening.

In order to feed openly during the daytime, caterpillars need some deterrent against predators. The most common form of passive deterrent is the possession of body hairs or spines that irritate a would-be predator. Most insectivorous birds avoid hairy caterpillars such as those of the drinker moth.

Weird faces The use of active defence towards predators opens the floodgates to a tremendous variety of shapes and colour forms. Active defence may be bluff or real but it is invariably successful. If molested, a well-camouflaged caterpillar of the elephant hawk-moth can suddenly turn into what looks like an imposing 'snake'. An equally frightening caterpillar is that of the lobster moth which, when alarmed, can assume a weird lobster-like shape. If the predator remains unmoved by this display the lobster moth caterpillar can reinforce its defence by squirting formic acid.

One of the most effective deterrents is found among the more spectacularly coloured caterpillars that use nature's international code telling all predators, 'Beware, I am poisonous'. Many of these caterpillars obtain toxins from their foodplants, while others make their own. The black and yellow caterpillars of the burnet moth, for example, feed on trefoils which contain cyanide compounds as a deterrent to grazing slugs. If a caterpillar of this type is handled roughly it will exude droplets of liquid which are very bitter tasting and induce vomiting in birds.

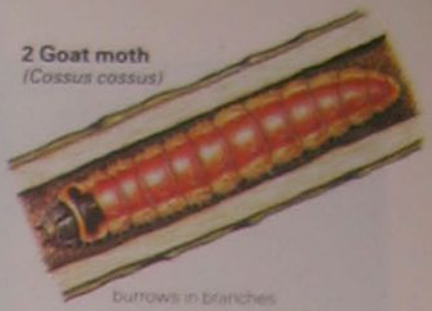
Caterpillar survival Despite the fantastic variety of shape and form, the vast majority of caterpillars end up as a meal for some other creature. A female moth or butterfly need only replace herself and her mate in order to maintain a constant population level from year to year. As each female lays around 200 eggs on average it is fairly normal that 198 of these will die or be eaten before reaching the adult stage.

Below: In common with most other brightly coloured caterpillars, those of the buff tip moth are highly poisonous–their vivid colours warning birds of the potential danger. Many of these poisonous species live communally to draw further attention to themselves.

Caterpillar types

All caterpillars have adopted ways of concealing themselves from predators as they go about their vital task of feeding. While the simplest caterpillars burrow into leaves and stems (**1-3**), others roll themselves up in leaves or spin webs (**4-6**). The next step in caterpillar protection is camouflage–to appear to be the same colour as the environment (**7-12**). More intriguing still are the caterpillars which are covered in irritant hairs (**13**) or those which are so brightly coloured that they warn their enemies away (**13b** and **16**). Finally, there are the species which adopt weird, alarming postures, and even squirt acid at their adversaries (**14-15**).

1 Green longhorn moth
(Adela viridella)



2 Goat moth
(Cossus cossus)

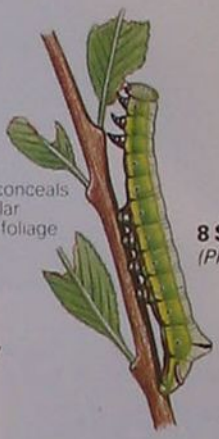
3 Currant clearwing
(Aegeria tipuliformis)

4 Bagworm
(Pysche casta)

5 Green oak-roller
(Tortrix viridana)

6 Small magpie moth
(Eurrhypara hortulata)

7 Meadow brown butterfly
(Maniola jurtina)



8 Swallow prominent moth
(Pheosia tremula)

10a Brimstone butterfly
(Gonepteryx rhamni)

9 Broom moth
(Ceramica pisi)

10b Purple emperor moth
(Apatura iris)

11 Early thorn moth
(Selenia bilunaria)

12 Swallowtail butterfly
(Papilio machaon)

13a Drinker moth
(Philudoria potatoria)

13b Yellowtail moth
(Euproctis similis)

14 Elephant hawk-moth
(Deilephila elpenor)

15 Puss moth
(Cerura vinula)

16 Magpie moth
(Abraxus grossulariata)

TURLOUGHS: IRELAND'S DRY LAKES

Turloughs–found in Ireland–are grassy depressions in porous limestone rock where underground water periodically wells up into temporary lakes.

Turloughs are so named for their dramatic habit of 'disappearing': the word is derived from the Irish *tuar loc*, meaning 'dry lake'. This apparent contradiction is scientifically explained by a combination of hydrological and geological factors–a permeable limestone rock, fluctuating water tables and hence fluctuating water levels on the surface. The rise and fall of the water and the duration and frequency of the flooding in turloughs all depend on the peculiar drainage patterns of these limestone regions.

Reported nowhere else in the world in this form, turloughs are most abundant in the limestone pavements of north County Clare and eastern County Galway–the area known as the Burren. Here, the bare grey rock, with few trees and little surface water, looks like a lunar landscape, apparently devoid of life. But this area is internationally famous and a treasure house for the botanist who can find, within a relatively small area, a rare combination of Arctic, Alpine and Mediterranean plant species.

Types of turlough These 'dry' lakes may be small or large, shallow or deep. They vary from saucer-like depressions in the ground, measuring only a few feet across, to large basins extending over several hundred acres of land. Rahasane Turlough is one of the largest, located between the towns of Kilcogan and Craughwell in eastern Galway. It is a great

Above: A turlough near Gort in County Galway, showing plant zonation from the submerged pondweeds (*Potamogeton* and *Elodea*) to emergent water plantain (*Alisma*). Notice how shallow the water is. In high summer (if there is no rain) it may well dry up altogether.

Below: Brent geese are among the wildfowl species that come to graze in winter on the grass of a dried-up turlough.

flat-bottomed basin, 3.2km (2 miles) long and just under a kilometre (half a mile) wide, with a depth of some 1.5m (5ft). (Some turloughs may be 9m (30ft) deep.)

The impressive Carran Depression, in the heart of the Burren, is another variation. This 60m (200ft) deep valley, with the village of Carran perched above the steep limestone cliffs, is of great interest to geologists and geographers alike. It is probably caused by collapse of a subterranean cave, deepened by further solution and erosion of the carbonate rock by acidic waters.

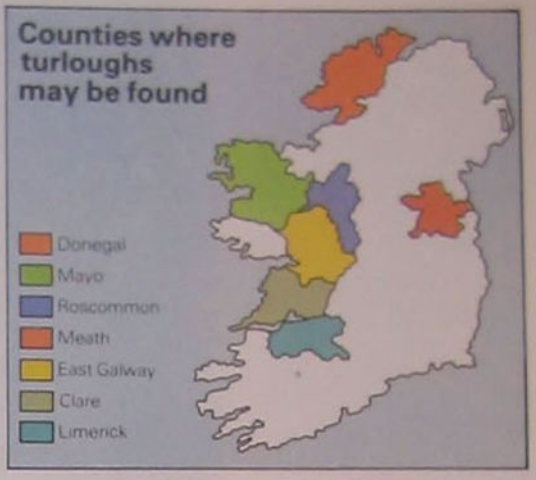
During the winter months of November to April turloughs are filled with water, fed through the subterranean passages which honeycomb the limestone rock beneath. During the summer months the turloughs empty through the same passages–often quite dramatically within a few days–and assume the appearance of grassy depressions in the surface. This periodic fluctuation in water level is not necessarily a seasonal one but rather related to rainfall patterns; as any visitor to Ireland will know, downpours are not at all uncommon during the summer months.

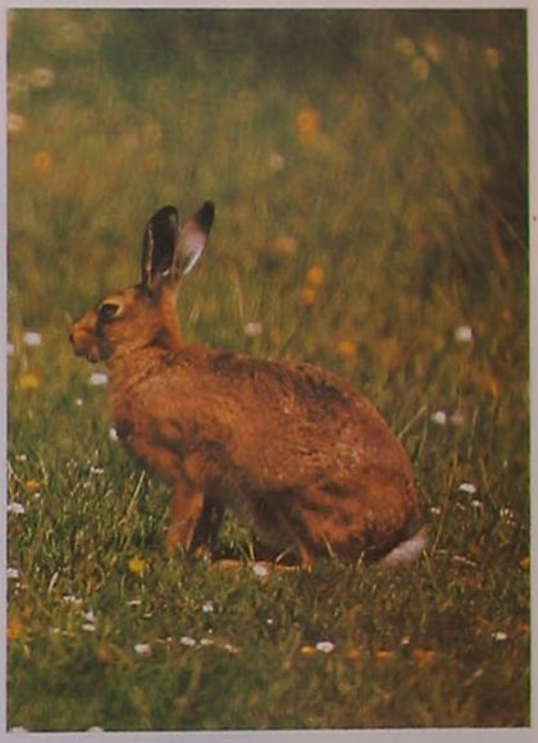
Some turloughs never dry out and hold a permanent, though shallow, lake throughout the year. Others may have a spring in the floor from which a stream of water flows, only to disappear a few feet further on into a swallow hole–a kind of in/out system. The Castletown River flows through the Carran Depression and provides a dramatic example of such a disappearing trick: the river rises in a group of springs at the northern end of the valley, flows on through and then plunges into a swallow hole at the southern end. The bottom of this valley contains several small turloughs, some permanently filled with water. During wet weather, much of the floor is flooded, often to 1.5m (5ft) deep.

Another interesting variation is Caherglassaun Lough, near Kinvara in eastern Galway. This turlough remains filled with water during summer and the water level can actually be seen to rise and fall by a few feet or so over a period of several hours. A network of underground passageways connects this turlough to the sea at Galway Bay, some 6.4km (4 miles) away, and the twice-daily fluctuation in water level at Caherglassaun is due to tidal influence. The water in the turlough is not, however, salty to the taste, so the seawater is obviously much diluted during its passage through the rock.

Grazing and soils The periodic flooding of the turlough basin and the thin limy deposits left behind promote the development of a rich grassy sward much favoured by local grazing animals, from cattle and sheep to rabbits and hares. During the summer Rahasane Turlough is alive with grazing animals–hundreds of horses, cattle and sheep, owned by local farmers and breeders, eat their way down to the last blade of grass. Due to this intensive

Right: Besides the Burren, turloughs are also found wherever limestone rock outcrops on the surface or is covered by a thin layer of soil or vegetation. Thus, turloughs are found scattered throughout western Ireland, in parts of Mayo, Limerick, Roscommon and Donegal. They are also found, though less concentrated, in eastern counties, such as County Meath. Since the central plains of Ireland are underlaid by limestone but covered by a generous layer of peat bog, turloughs are rarely seen here, but a few may exist.
All karst or limestone regions of the world probably have similar features. For example, the tarn lakes of the Ingleborough area in Yorkshire are superficially akin to turloughs, as are the poljes of Yugoslavia. But the exact hydrological conditions, especially the drainage patterns, characteristic of turloughs have only been described in Ireland to date.





Centre right: A brown hare–one of the many animals that graze the turlough grass down to bare soil.

Below: The 'turlough' violet (*Viola stagnina*) covers the slopes of many of the dry lakes in early summer with its pale blue flowers.

Above: A golden plover may come to feed on the insects found in turloughs.

Left: Blackthorn in bloom –this species grows on the upper slopes of turloughs.

Below: A turlough shrinking rapidly–the boulders in the foreground (now high and dry) are submerged in winter and covered with the aquatic moss *Fontinalis*. Any animals and plants in the turloughs must be able to withstand this dramatic change from wet to dry.

grazing, the vegetation of turloughs is nearly always stunted and dwarfed.

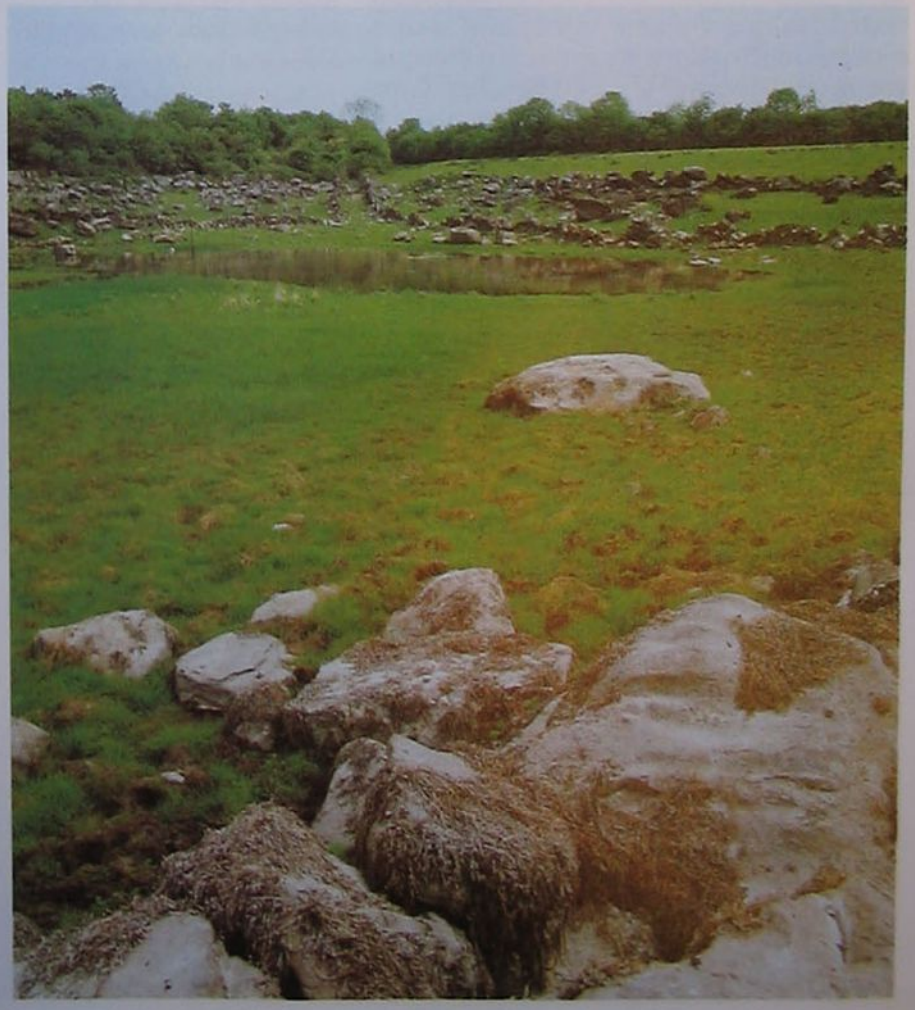
Except for isolated pockets, turlough soils are usually thin and poorly developed. They lie either directly on the bedrock or above sediments of varying thickness. These sediments consist of glacial drifts and, below this, typical lake deposits such as marls and silts. Marls are fine limestone, white in colour; on sunny days a soft pearly lightness is imparted to the waters of certain turloughs with marly bottoms. Since water drains away freeely through marls, the soils of such turloughs retain little water and dry out easily. The floor of a turlough may be covered with grassy vegetation or with muddy rocks, which often indicate the position of the turlough's swallow hole. Sometimes, the soil in the very bottom of a turlough remains waterlogged in summer and this has allowed peat to develop over the centuries.

The plant zones Although they do not have a unique flora and fauna, there are a few species of plants and animals closely associated with turloughs and which are rarely found elsewhere. The critical factors for life in these ephemeral lakes are, of course, the alternate periods of flooding and drying-out and the adaptability to survive under such stresses. Even within a dry period, local variations in the water table may cause a turlough to flood again suddenly and such temporary changes have to be coped with.

From the botanist's point of view, the slopes of a turlough provide a fascinating zonation of plant life. The zones are usually quite distinct, with one type of plant ending abruptly and another taking over.

On the upper slopes of the turlough a few small scrubby trees manage to grow in the shallow soils. The most common are hawthorn, blackthorn and purging blackthorn, sometimes accompanied by ash. Willows and alders, common elsewhere, never grow here. There is some evidence to suggest that there would be more trees were it not for the intense grazing of the turloughs during the year. The dewberry, a relative of the blackberry and with equally edible fruits, is also a common plant associated with turloughs at this level. During winter flooding, the trunks and roots of the trees may be submerged for months at a time.

Below the tree zone, in the middle reaches of the turlough's slopes, carnation sedge and autumn hawkbit are common. The so-called turlough violet (*Viola stagnina*)–the fen violet



of England–is locally abundant. Another violet species, the heath dog violet (*V. canina*), also grows in this zone and where the two species occur together, hybrid violets have developed in great abundance.

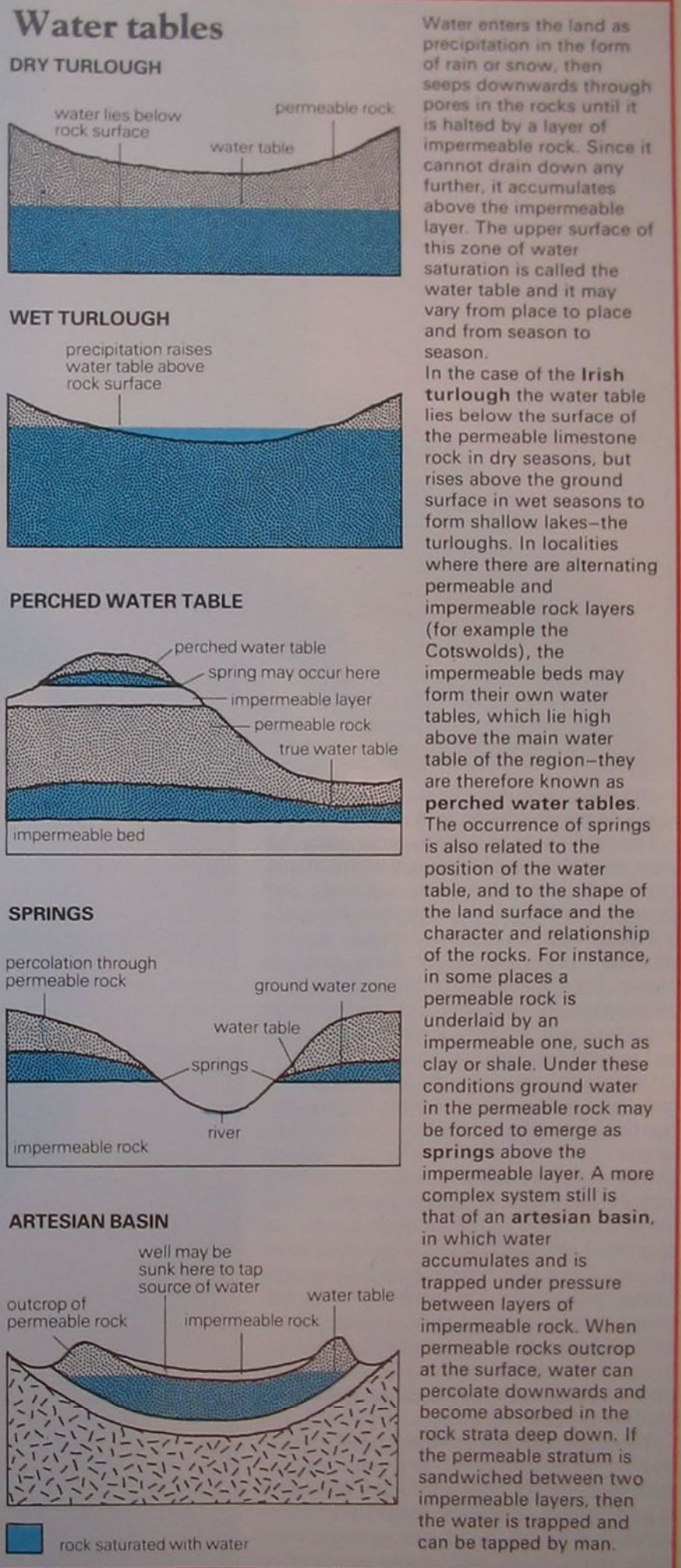
Silverweed abounds further down the slopes, and when the turlough dries out this plant, together with creeping bent grass, may cover the entire bottom of the basin. In wetter soils or turloughs which hold a permanent lake, typical aquatic species are present–floating sweet grass, floating fox tail, fool's watercress, shoreweed and amphibious bistort. Other typical marsh plants are also found–pondweed, water crowfoot, large sedges and marsh marigolds. One of the striking features of turlough flora is the abundance of such typical grassland species as creeping buttercup, silverweed and bent grass in situations where these plants are inundated for half the year and yet can withstand drought at other times.

A black moss, called *Cinclodotus fontinaloides*, is another species closely associated with turloughs. In fact, the site of a turlough can often be spotted from a distance by the presence of this black moss growing in a roughly circular pattern around the rim of the basin. It is a most adaptable moss, growing on the tops of the grey limestone boulders almost throughout the depth of the turlough. Those patches lying out of water simply dry up and wait. Another moss, the water moss *Fontinalis antipyretica*, also features in turloughs; it is less tolerant of drying out and forms green patches on the sides of submerged boulders and on the damp floors.

Animal life To the casual observer, turloughs may appear devoid of animal life, with little to be seen in their clear waters. Animal life in these basins depends on many factors, such as the state of the turlough at a particular time of year, the frequency of flooding, the nature of the bottom sediment, the size of the basin and its surroundings. Obviously, the alternate flood and drought conditions in a turlough affect the animal life as much as the plants, suiting neither aquatic nor dry-land species unless they are fast breeders and can complete their life-cycle in a few months. Fish and water snails thus tend to be absent.

However, the numbers of aquatic animals make up for their lack of variety. Large populations of water fleas and related small crustaceans abound in the water, feeding on decomposing faeces (provided by the summer grazers) and decaying plant remains. Winged adult insects, such as water bugs and water beetles, fly to the turlough and feed on the microscopic planktonic life or prey on the crustaceans. Dragonflies and mayflies hover over the water and their nymphs develop to adulthood there. One opportunistic dry-land animal, typical of turloughs, is the ground beetle, a small and active carnivore. It hibernates in winter above the turlough and becomes active in spring when the receding

Water tables



Water enters the land as precipitation in the form of rain or snow, then seeps downwards through pores in the rocks until it is halted by a layer of impermeable rock. Since it cannot drain down any further, it accumulates above the impermeable layer. The upper surface of this zone of water saturation is called the water table and it may vary from place to place and from season to season.

In the case of the **Irish turlough** the water table lies below the surface of the permeable limestone rock in dry seasons, but rises above the ground surface in wet seasons to form shallow lakes–the turloughs. In localities where there are alternating permeable and impermeable rock layers (for example the Cotswolds), the impermeable beds may form their own water tables, which lie high above the main water table of the region–they are therefore known as **perched water tables**. The occurrence of springs is also related to the position of the water table, and to the shape of the land surface and the character and relationship of the rocks. For instance, in some places a permeable rock is underlaid by an impermeable one, such as clay or shale. Under these conditions ground water in the permeable rock may be forced to emerge as **springs** above the impermeable layer. A more complex system still is that of an **artesian basin**, in which water accumulates and is trapped under pressure between layers of impermeable rock. When permeable rocks outcrop at the surface, water can percolate downwards and become absorbed in the rock strata deep down. If the permeable stratum is sandwiched between two impermeable layers, then the water is trapped and can be tapped by man.

waters leave small crustaceans stranded at the edge and prey to the ground beetle.

The swallow hole is a favourite place for some animals to survive periods of drought in a turlough. Black flatworms, water lice and shrimps may live here; competition for space and food must be extreme in these narrow crevices, which effectively form summer prisons for these animals. When there is a permanent lake present or a river connection to the turlough, sticklebacks are found, living and breeding there all year round.

One animal which has been found only in turloughs is the fairy shrimp *Tanymastix*. Nearly 2.5cm (1in) long, this animal is the largest of the invertebrate fauna and spends its whole life-cycle in the turlough. During dry periods the drought-resistant eggs lie buried in the soil. As soon as the turlough floods, the eggs hatch, releasing tiny shrimps which swim up into the water and become fully grown within two months. The adults die when the waters recede, but first they produce thousands of eggs which will not hatch until they have gone through a period of desiccation, thus ensuring the survival of the species for another generation.

Threats to turlough survival In recent years, due to programmes of draining and reclamation, many turloughs have been destroyed. In fact, Rahasane is the only surviving large turlough in the country and is itself under threat. It has long been a major feeding ground for wildfowl wintering in Ireland, especially the Greenland white-fronted goose. Thousands flock here in winter to feed on the rich grassy vegetation and hence Rahasane is recognised as a site of international importance for environmental conservation.

No comprehensive study has been undertaken in Ireland to assess the exact benefits to agriculture that arterial drainage will provide, yet indiscriminate destruction continues.

Above: Burren limestone with a marl-bottomed, pale pearly blue turlough in the distance. (Marl is a fine white limestone.) Water drains freely through marls so such lakes are often dry.

Below: Amphibious bistort –a typical turlough plant.

GREEN ALGAE AND THEIR LIFE-CYCLES

Green algae are among our most primitive plants yet many have strange, complicated life-cycles in which the same species looks totally different at different stages–for a long time, indeed, scientists thought they were separate species.

The green seaweeds of the seashore and the powdery green coating sometimes seen on tree trunks both belong to the same class of plants –the green algae, known to scientists as Chlorophyta. The green colouring comes from the presence of chlorophyll in the cells, a feature the green algae share with most land plants. The other two major groups of algae– the red algae (Rhodophyta) and brown algae (Phaeophyta), better known as red and brown seaweeds–also contain chlorophyll though its green colour is masked in these two groups by the presence of other pigments. Despite the fact that they are all commonly known as algae, the green algae are not very closely related to the reds and browns. With their green colour, their cellulose cell walls and starch as the end product of photosynthesis, it has been suggested that green algae are more closely related to mosses, ferns and other land plants.

Varied habitats Most green algae grow in aquatic habitats, in both fresh and salt water. A few occur in the soil, usually in damp shaded situations, and the single-celled alga, *Chlorococcum*, is often seen as a green layer on the sides of tree trunks. A range of other species inhabit puddles, bogs, ponds, ditches, rivers and lakes.

The larger green algae in the sea, brackish water and saltmarshes are known as seaweeds. Green seaweeds are not as prominent on open seashores as brown seaweeds. Nevertheless they are commonly found on rocks under the cover of larger brown seaweeds, and also in rock pools, crevices and gullies. On the sea-bed some species can grow at considerable depths. In tidal estuaries, green seaweeds such as gut laver can form dense growths along

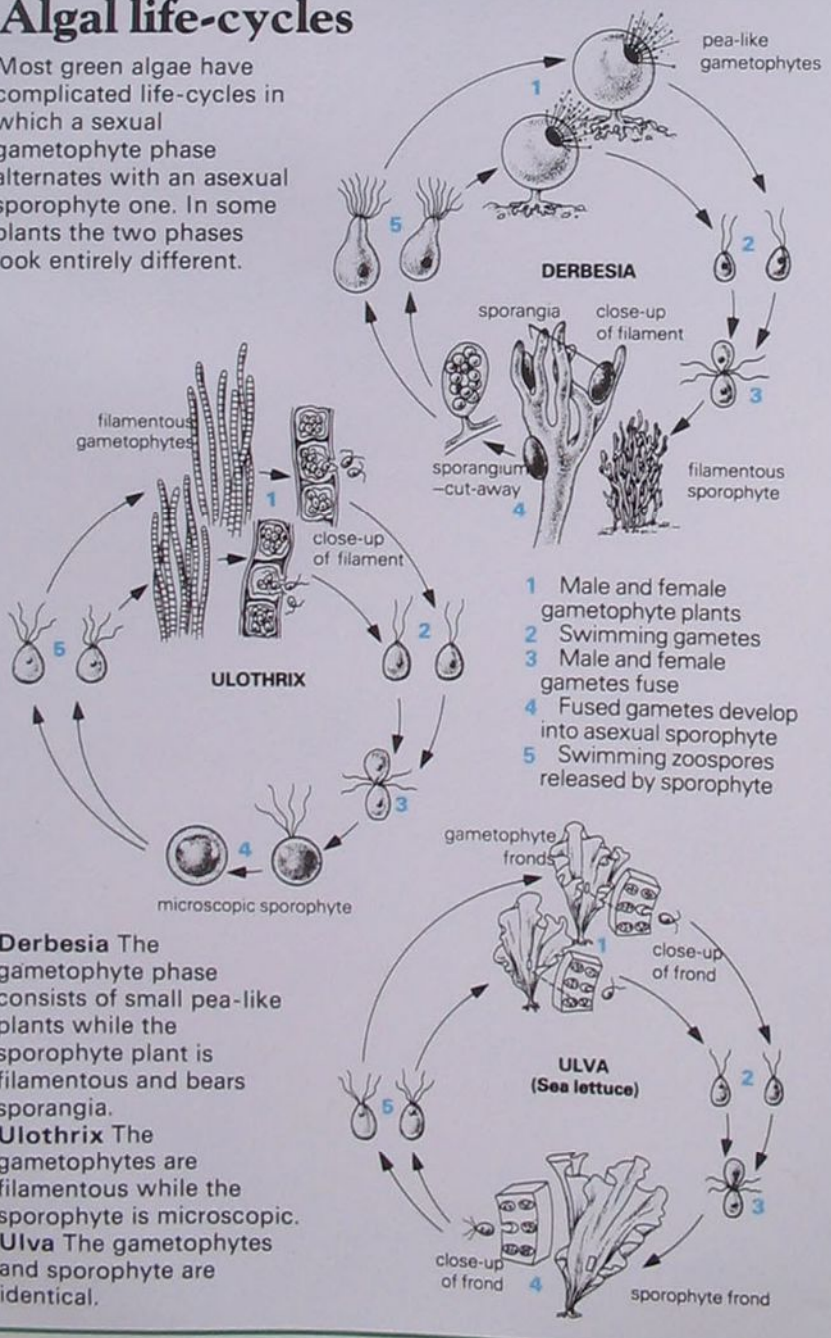
Below: Gut laver in a rock pool on the Kirkcudbright coast. As in its close relative, sea lettuce, the frond is just two cells thick. But, whereas in sea lettuce the frond is flat, in gut laver the two cell layers separate so that the frond is hollow and tubular, looking like a piece of intestine.

Right: The green seaweed *Cladophora* in a rock pool. This is one of the few species of green algae that can survive in both fresh and salt water. It grows to a length of 15cm (6in) and consists of very fine, branched filaments. Also in the rock pool is bladder wrack (*Fucus vesiculosus*).

Below right: Bubbles produced by gut laver photosynthesising in a shallow rock pool. Both gut laver and sea lettuce are important food sources for gulls, geese and waders, which can often be seen browsing on the extensive growths of these plants in estuaries.

Algal life-cycles

Most green algae have complicated life-cycles in which a sexual gametophyte phase alternates with an asexual sporophyte one. In some plants the two phases look entirely different.



Derbesia The gametophyte phase consists of small pea-like plants while the sporophyte plant is filamentous and bears sporangia.
Ulothrix The gametophytes are filamentous while the sporophyte is microscopic.
Ulva The gametophytes and sporophyte are identical.

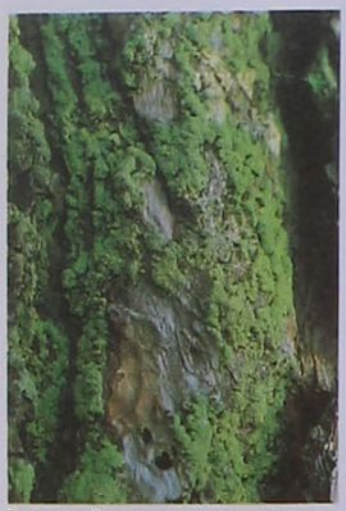
river walls. The same species are also found as mats of vegetation on mudflats and growing among higher plants on saltmarshes. Some species of green algae are restricted to either saltwater or freshwater habitats, while a few (such as gut laver) can grow in both.

Varied forms Green algae are an extremely diverse group. The smallest members are microscopically small, single-celled organisms. An example is *Chlamydomonas*, which moves by means of a pair of beating flagellae. *Volvox* is an aggregation of *Chlamydomonas*-like cells forming hollow spherical colonies which, growing to a diameter of 1mm, are just visible to the naked eye. The cells are embedded in a viscous substance and the outward-facing flagellae beat in unison to provide the means of propulsion. The single-celled *Chlorococcum* of tree trunks, by contrast, does not move since it does not possess flagellae. Another group, the desmids, are free-floating green algae, mostly single-celled, although they sometimes unite end to end to form a filament-like colony.

Many other green algae are truly filamentous. Some, such as *Chaetophora*, are microscopic and form tufts on other, larger, algae or on higher plants. Others are much larger, the

Right: Sponge tang consists of forked finger-like projections which have a spongy texture due to the presence of hundreds of tiny siphons packed together. This is a purely marine alga, growing on mud, sand and rocks on the coast and on the sea-bed down to a depth of 20m (65ft).

Below: Most green algae live in aquatic habitats but an exception is *Chlorococcum*, a single-celled species often seen as a green powdery coating on tree trunks.



Below: Stoneworts are the most highly evolved of the green algae. Shown here is one species, *Chara vulgaris*, in a New Forest pond. Note its whorls of branchlets surrounding the main stem.

freshwater *Spirogyra*, for example, having filaments up to 10cm (4in) long which form masses resembling cotton wool. *Chaetomorpha melagonium*, a marine species found on the sides of rock pools, consists of coarse, unbranched filaments resembling a bristle, while the widespread genus *Cladophora* is made up of branched filaments.

Rather different is the sea lettuce (*Ulva lactuca*), which has a flat, lettuce-like leaf called a frond, which is only two cells thick. This plant is also known as oyster-green because it was used to decorate oyster stalls in market places. A close relative is gut laver (*Enteromorpha intestinalis*), which differs from sea lettuce in having a tubular frond.

Some green algae have quite a different type of structure, being formed of non-cellular branched tubes called siphons–filamentous structures superficially resembling the hyphae of a fungus. An example is *Bryopsis plumosa*, an attractive, delicate, feather-shaped plant which measures up to 10cm (4in) and grows on the sides of rock pools and on the sea-bed. *Derbesia* siphons, by contrast, form irregularly branched tufts. Sponge tang (*Codium fragile*) is a much larger plant, sometimes growing to a length of 1m (3ft).

The most highly evolved green algae are the stoneworts, which are, indeed, sometimes classified as a class apart from the green algae. Structurally they are much more complex, superficially resembling horsetails. The genus *Chara*, for example, is recognised by its distinct main stem with whorls of branchlets often bearing reproductive structures.

Algal reproduction The primitive single-celled algae such as *Chlamydomonas* and *Chlorococcum* reproduce mainly by simple cell division–in other words, non-sexually. Higher green algae also reproduce sexually in a complicated life-cycle that involves alternating sexual and non-sexual phases. In sea lettuce, for example, the plant in its sexual (gametophyte) phase produces male and female sex cells called gametes. These fuse and grow to form a non-sexual, spore-producing plant called the sporophyte. The sporophyte plant looks exactly like the gametophyte plant but, instead of releasing sexual gametes, it releases non-sexual zoospores. These eventually settle and grow into the gametophyte plant, which completes the cycle. Both the gametes and the zoospores are known as swarmers; masses of them can sometimes be seen as a green scum on the surface of water.

In a few species, the gametophyte plant and the sporophyte plant look quite distinct. For example, the filamentous *Derbesia* is actually the plant in its spore-producing phase. The gametophyte is a small spherical pea-like structure and was considered to be a quite separate species until the 'pea' was seen in a laboratory to release gametes that produced the filamentous form.

Most green algae are annuals, and in some cases the life-cycle is completed within a matter of weeks, allowing several generations within a year. However, a few, such as *Codium*, are perennials.

Uses to man Despite their widespread occurrence, green algae are not as commercially important as red and brown algae. Some have been used for manure and as animal fodder, and the Japanese consider some members, such as sea lettuce, to be a great delicacy, though the British generally have no taste for them. Sea lettuce was, however, once eaten as a soup or salad in Scotland.

Fouling On the other side of the coin, green algae can be a considerable nuisance as fouling organisms. They often appear in freshwater aquaria and fish ponds–much to the annoyance of the owners–and extensive growths of *Cladophora*, known as blanket weed, develop in nutrient-rich streams and ditches, usually near land where fertilisers have been extensively applied. These growths often choke the water course, eliminating its natural flora and fauna.

FUMITORY: SMOKE OF THE EARTH

Pull up a fumitory and you will immediately notice a strong, acrid smell coming from the roots. This, plus the smoky-looking, grey-green foliage of many species, accounts for the common name of these plants, which means 'smoke of the earth'.

Right: Up to 20 pink, dark-tipped flowers of common fumitory may be found on one head. Beneath are the globe-shaped fruits.

Recently ploughed land nearly always produces an abundance of interesting plants. Most are fairly well known and easily distinguished, but there is one group of arable weeds that can make an aspiring field botanist wish for a rapid change of hobby. These are the fumitories–the members of the genus *Fumaria*. Ten species of this genus are found in Britain and it is always 'the eleventh' that the poor innocent botanist first encounters in the wild.

The fumitories are a small group of plants, in classification systems placed between two large families, the poppy family and the cabbage family. The basic shape of the plant is common to all ten species. The leaves are finely divided into lobes and are greyish-green in colour. The size and shape of the lobes are often of great importance when separating the individual species. The flowers, often as many as 40 at a time, are borne on an inflorescence, which is always situated opposite a leaf.

Individually, the flowers are very small, usually less than 12mm (½in) long. Each has four petals arranged to form a narrow tube. The topmost petal of this tube has a short blunt spur at the rear containing nectar. Yet it seems to have very little effect in attracting pollinating insects and cross-pollination rarely occurs. This is, however, a common situation among annual weeds of disturbed ground, where self-pollination seems to be the rule rather than the exception.

British species The species you are most likely to come across is common fumitory (*Fumaria officinalis*), which is found on light soils throughout the British Isles, though it is more frequent in the east of the country than the west. It has leaves with flat lance-shaped lobes, bracts that are shorter than the fruit stalk and a pink, dark-tipped flower up to 9mm long.

The next most common species, *F. muralis*, neatly illustrates the difficulty of the genus, for it has three subspecies in Britain, two of which are very variable. The most common of these is *F. muralis* ssp. *boraei*, which can vary from being a slender plant to a robust one. It has oblong, lance-shaped or wedge-shaped leaf

Five fumitories
1 Ramping fumitory (*Fumaria capreolata*). Scattered distribution throughout the British Isles.
2 *Fumaria purpurea*. Endemic species (ie, native only to the British Isles). Scattered.
3 *Fumaria parviflora*. Confined mainly to arable and chalk land in south-east England.
4 *Fumaria occidentalis*. Rare plant found only in Cornwall. Endemic.
5 White climbing fumitory (*Corydalis claviculata*). Scattered throughout the British Isles, but never common.

Above: The West Country, and Cornwall in particular, has a greater variety of fumitories than any other part of Britain. Both *F. martinii* and *F. occidentalis* are confined to this part of the country, and the plant shown above, *F. bastardii*, has a scattered, though markedly western, distribution. Like most fumitories, it flowers throughout the summer and into autumn.

Opposite left: Yellow fumitory, an introduced species of *Corydalis* native to southern Europe. Unlike our own native white climbing fumitory, this species lacks tendrils with which to cling on to supporting plants.

lobes and narrow pointed bracts which are usually a little shorter than the fruit stalk. The flowers are 1-2cm (about ½in) long.

Probably the most easily distinguished member of the genus is ramping fumitory (*F. capreolata*), a robust climbing plant often 1m (3ft) tall. Apart from its vigorous habit it can be told apart by its dense heads of small, creamy-white flowers, tipped with dark pink, and by its drooping fruits. It is never very common, however, and seems to show a marked liking for disturbed ground in coastal areas.

Of the other fumitories, *F. occidentalis* and *F. martinii* are very rare, while *F. vaillantii* is uncommon and confined mainly to chalk arable land in the south and east of England. *F. purpurea* is much more common and resembles ramping fumitory except that it has pink flowers. Finally, *F. parviflora* and *F. micrantha* have a south-easterly distribution while *F. bastardii* is found mainly in the west.

Smoking fumitories The name 'fumitory' comes from the Latin for 'smoke of the earth', but why the plants should be so called is a matter for some contention. The most obvious reason is that, with their smoky grey-green leaves, large numbers of fumitories covering a piece of bare earth look like a layer of smoke hanging inches above the ground. Another possible origin lies in the fact that the roots of a fumitory plant give off a pungent smell when pulled out of the ground–hence 'earth-smoke'. Lastly, the plants have an acrid sap that makes your eyes water if it gets into them, in the same way as smoke.

Family relatives In the same family as *Fumaria* is the genus *Corydalis*, three species of which grow in Britain. Two are introduced species and the third is native. The introductions are yellow fumitory (*C. lutea*), which looks very much like a yellow version of an ordinary fumitory, and *C. solida*, which is similar to *lutea* except that it has purple flowers with a long straight spur.

The native member of the trio is white climbing fumitory (*C. claviculata*), a scrambling plant looking like a long thin species of *Fumaria*. The flowers are very similar and are borne in an inflorescence of about six. The leaves are less divided than those of *Fumaria*.

Herbal uses In his *Canterbury Tales*, Chaucer makes reference to fumitory as a laxative: 'A day or two ye shul have digestynes, of worms er ye take you laxatyves, of lauriol (almost certainly spurge laurel), centaure (centaury) and fumetere.' Much later, William Meyrick, whose *Family Herbal* of 1790 pulled together much herbal knowledge of the 18th century, wrote that 'some people smoak the dried leaves in the manner of tobacco for disorders of the head, and frequently find relief.' One suspects that if these head disorders had been caused by trying to identify one fumitory too many, there would be little hope of relief! It does, however, add a new dimension to the name 'smoke of the earth'.

SEA-URCHIN DEFENCE SYSTEMS

To help them survive the hazards of sea-bed life, sea-urchins have evolved a remarkable array of tiny pincer-like defence organs.

Right: Protruding beyond the mass of spines of this edible sea-urchin (*Echinus esculentus*) you can see the thin, prehensile tube-feet. These are not defensive organs: their main function is to feel round for hard surfaces, grip them and pull the animal along.

Below: A closer view of a living sea-urchin. Hidden among the bases of the spines, still too small to be clearly seen, are the various kinds of pedicellariae.

Adult sea-urchins are cumbersome bottom dwellers that move slowly over the sea-bed in search of food and shelter. Although life on the sea-bed is not fraught with the hazards of temperature and salinity changes found on the shore, the sea-bed habitat does present other problems. Sea-urchins are at risk from other echinoderms–mainly starfishes–which feed upon them. For example, the edible sea-urchin is liable to be attacked by the common starfish, while the green sea-urchin is often a victim of the spiny starfish.

Predation is not the only problem. The vast majority of bottom-dwelling marine animals reproduce themselves by means of myriads of planktonic larvae, and many of these need a hard surface on to which they can settle and attach themselves at metamorphosis. Echinoderms, such as the sea-urchins, are potential landing sites for these tiny intruders, and need to protect themselves from the encrustation that their growth would cause. A third hazard is that sea-bed animals are at times showered with particles of silt. Heavy silting on a sea-urchin would impede its water intake, which is vital to its existence, as well as its food intake. Sea-urchins live successfully under these conditions, and this prompts the question how they cope with these hazards on the sea-bed.

The sea-urchin's twofold armoury As a first line of defence, sea-urchins are covered with long, sharp spines, which deter large opportunist predators such as fishes that lack the specialised techniques required for eating a sea-urchin. Starfishes, however, are able to insert the tips of their arms in between the spines. This would enable them to feed easily on their victims if it were not for a second line of defensive organs, the pedicellariae.

Pedicellariae of sea-urchins are minute, pincer-like organs, usually with three jaws that open and close. These are borne on flexible stalks that pivot on a minute boss on the main skeleton (test) of the sea-urchin. With the help of a good hand lens, you can just discern them between the bases of the spines of a live specimen. The smallest are less than a millimetre in length, while the largest are under three millimetres. There are four

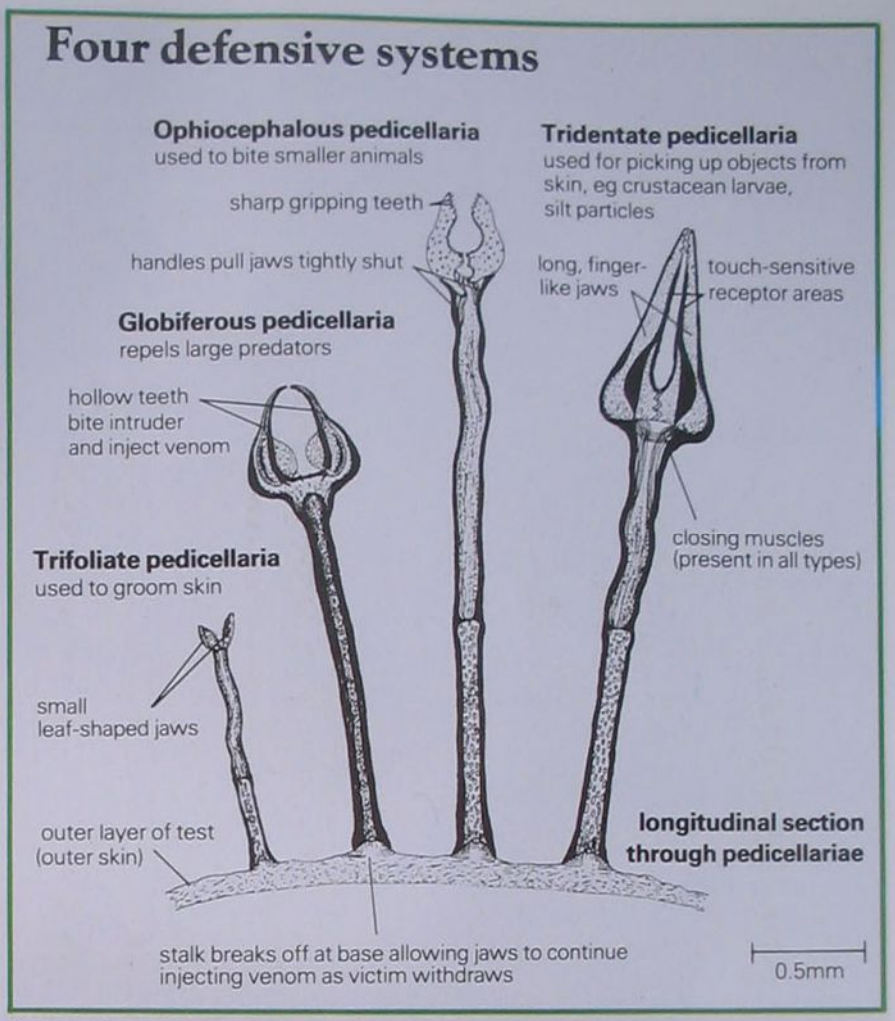
distinct types of these intricate defence organs.

The cleaners The tridentate pedicellariae are the tallest kind, and have long, finger-like jaws. Their principal function is to remove small items such as silt particles and the settling of larvae of other marine animals. The jaw blades are touch-sensitive, particularly towards their tips and on the inner faces, so that any tactile stimulus causes them to snap shut and sieze the intruding object. Minute nerve tracts run from the tips of the blades to the muscle blocks at the base of the jaws, and when the stimulus occurs two groups of muscles close the jaws; one group snaps the jaws together, and the other holds them shut after they have closed.

After the intruding object has been removed a third set of muscles opens the jaw again. The point about which the jaws hinge is called the fulcrum; this intricate structure consists of a set of cog-teeth on each jaw. Each set interlocks perfectly with its partners and allows precisely equivalent movements to be transmitted from one jaw to the next so that there is perfect opening and closing.

The trappers The second type, the ophiocephalous pedicellariae, are similar to the tridentates but their jaw blades are shorter and rounder, and carry gripping teeth which mesh together like the teeth of a man trap. Their function is indeed to trap intruding animals, mainly small crustaceans such as copepods and small shrimps.

The bases of these jaws have an additional structure called a handle, over which a minute ligament in the stalk passes. If these ophiocephalous jaws seize the leg of an intruding animal and this then tries to escape, the tension in the stem and in the ligament is increased. This increase in ligament strain is transmitted by the handles to the jaw blades, forcing them to close more tightly.



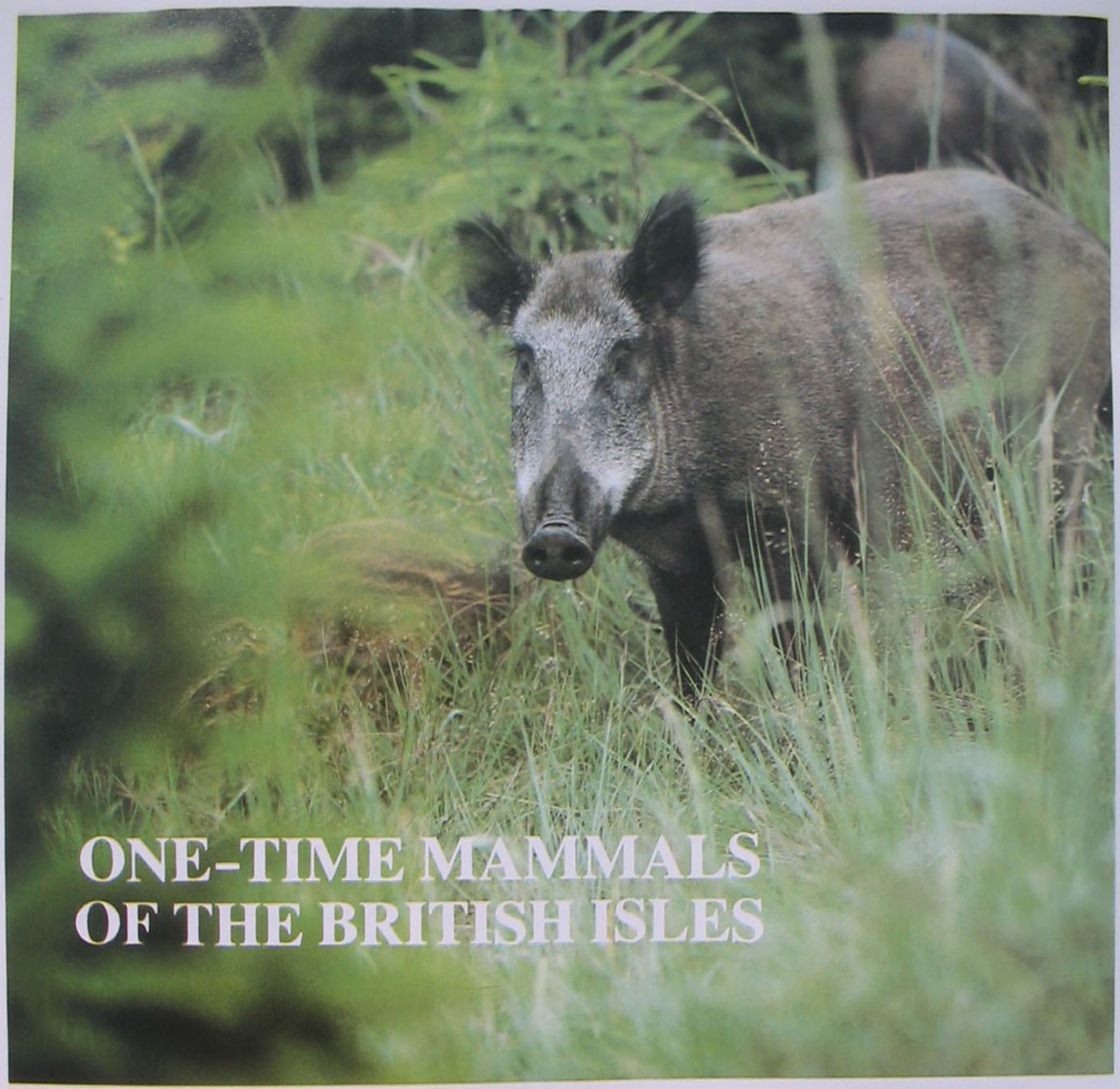
Below: Two green sea-urchins (*Psammechinus miliaris*) gripping the side of a rock. A few strands of seaweed are entangled among their spines, but otherwise they are clearly free from any encrusting organisms.

The poisoners The globiferous pedicellariae are a defence against larger predators, mainly starfishes. They are the only ones which can readily be pulled free from the urchin's test. They also differ from the others in that their jaws carry venom sacs. This venom can be injected into the tissue of a predator.

Special chemical receptors on the insides of the jaws are sensitive to certain chemicals in the skin of natural enemies such as starfishes, whose appearance triggers off the venom response in these pedicellariae. Once they have closed upon an object such as the tube-foot of a starfish, they do not open again, and as the starfish withdraws they break free from the test and continue injecting their venom as the intruder makes off.

The groomers Trifoliate pedicellariae, unlike the other three kinds, are spontaneous in action and do not require a stimulus to set the jaws in action. These are the smallest and most numerous pedicellariae on the urchin's test. By their constant action, these minute organs groom the urchin's skin, keeping it free from silt and bacteria.

A remarkable feature of some of these pedicelliariae is that their inner faces are inhabited by communities of minute protozoan animals known as thigmotrichs. It is possible that these act as 'biological dustbins', eating up the bacteria that are collected by the jaw blades.



ONE-TIME MAMMALS OF THE BRITISH ISLES

Many of the mammals that have lived in the British Isles for thousands of years are now extinct, but some of those remaining today have a very long history.

During the past two million years, known as the Pleistocene Epoch, Britain's environment has been radically different from that of today. There has been a series of ice ages (glacial periods) interspersed with warm periods (interglacials). The last Ice Age ended about 10,000 years ago with the beginnings of the warm period in which we now live. In the last 40,000 years Britain's fauna has included many species of large mammal; some, such as the giant deer and woolly mammoth, are now extinct, while others, such as the reindeer and wolf, are still found abroad.

In the periods of extreme cold, such species as polar bear, musk ox, reindeer, arctic fox and lemming have survived here, being well-adapted to tundra or high Arctic conditions, though there is little direct evidence available. There is more positive proof, from skeletal remains in cave deposits, that other mammals such as woolly rhinos, elephants and hippos, normally associated with much warmer climates, also once lived in Britain. They were here during the warm conditions of the last interglacial period, which lasted for 30,000 years until the onset of the final Ice Age of the Pleistocene about 70,000 years ago.

The last Ice Age During this most recent period, (from 70,000 to 10,000 years ago) the ice cap covered Scotland and most of Ireland and Wales, apart from the extreme south, and in England most of the area north of a line

Above: A wild boar and (bottom right) a beaver–both species that appeared in Britain in post-glacial times after the Ice Age ended 10,000 years ago. The beaver was later hunted to extinction because of the high value of its pelt. In 150AD, during the reign of the Welsh King Hywel Dda, a single beaver skin was worth five times that of an otter, and fifteen times as much as those of wolves and foxes. The last reference to beavers in Britain was made in 1188 in Wales. It was already extinct in England.

joining Bristol to Newcastle as well as a narrow belt along the east coast down to Norfolk. Even in areas south of the glaciers the average temperatures in England and Wales may have been as low as –17°C (1.4°F), with permanently frozen subsoil (permafrost) throughout. The vegetation was reduced to a thin covering of arctic tundra and open steppe grassland.

However, conditions at this time were not uniformly cold since there were short warm periods when the arctic mammals were joined by fauna from more temperate areas. They moved freely across the land between Europe and mainland Britain and Ireland and, as the climate improved, many large herbivores arrived to take advantage of the rich grasslands which were replacing the tundra. Around 40,000 years ago, the wild horse, woolly mammoth, rhino, reindeer and maybe giant deer were all present, possibly with such predators as the hyena, lion and lynx.

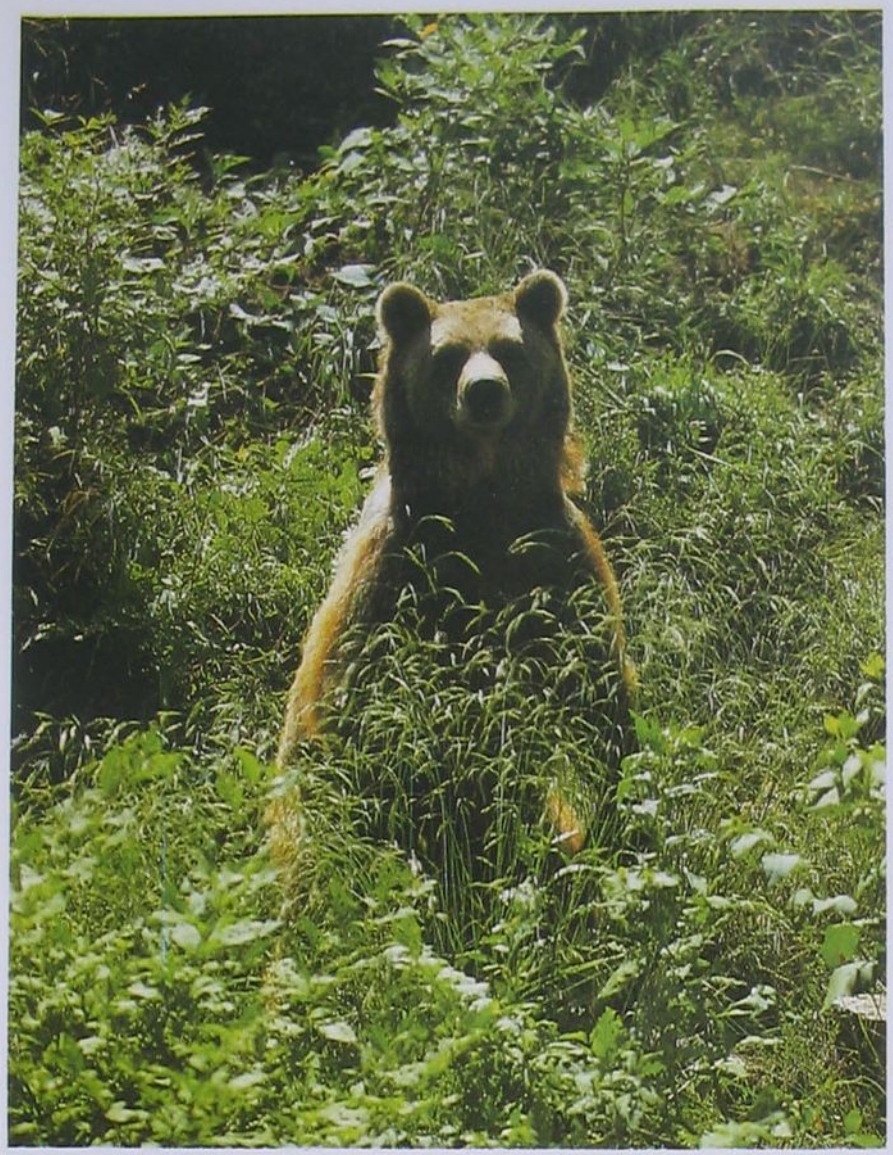
Glacial conditions then returned once more, and remained severe until 12,000 years ago, when the climate started to warm up. As before, land bridges allowed easy access to Britain, and large numbers of mammals such as giant deer, wild horse and reindeer rapidly moved in as the vegetation became more favourable. Birch and other woodland provided cover for elk, wolf, bear, red fox and possibly lynx. Apart from the upland areas which remained completely treeless, and the south east where pinewoods started to grow, most of Britain became covered with a mixture of grassy tundra and birchwoods. In the open tundra of the upland regions lived the arctic fox and its main prey, the varying and the Norway lemmings. Elsewhere, in more forested areas, other small mammals such as the common shrew and bank, field, water and root voles occurred, and all but the last are still here today.

Above: Reindeer in Scotland today. Herds of reindeer and wild horses ranged across the open areas of Britain, probably making regular migrations to their summer feeding grounds, as the reindeer still does in its present range. They were hunted by nomadic Upper Palaeolithic man, who probably accompanied the herds, just as the Lapps follow reindeer today.

Left: Wolves often prey on domestic animals, which has resulted in their persecution throughout history. The last British wolf died in Scotland in 1743.

Giant deer In Ireland, birch trees only really developed in the south. This may be one reason why the giant deer, or Irish elk, was apparently so much more common in Ireland and the Isle of Man than in mainland Britain, the species generally preferring a more open habitat. Its massive antlers, spanning up to 4m (12ft) and weighing over 45kg (100lb), and its height of over 2m (6½ft), probably would have made movement through dense woodland difficult. In Ireland it had become extinct well before the first human settlers arrived around 9000 years ago so that, here at least, man cannot have been responsible for its demise, although hunting raids from mainland Britain may have speeded up its decline. The extreme cold of the following period, the Younger Dryas, is generally thought to have been the main cause of its extinction in Britain.

The Younger Dryas This period is so-called because of the predominance of the pollen of *Dryas octopetala* (mountain avens) in this pollen zone, which spanned the following 500



Above: The brown bear was certainly common here in Roman times and may have survived into the 11th century in parts of Scotland.

Above right: A tooth of a mammoth found in a gravel pit. Mammoths became extinct in Britain about 10,000 years ago.

Left: A wildcat on a reserve in western Scotland. Wildcats are now uncommon as their habitat has been destroyed by man.

years (10,800-10,300 years ago) before the last Ice Age finally ended. The birch forest was replaced by tundra and many other mammals were pushed back as the glaciers advanced once more.

The first evidence we have of red deer, steppe pika, stoats, weasels and northern voles date from this time as, too, may the wolverine. Of these species, the northern vole, the steppe pika and the wolverine were unable to survive into post-glacial times in Britain, although they still exist elsewhere. The presence of the steppe pika indicates the kind of open steppe country which must have existed over much of the land. This member of the hare and rabbit family now occurs in central Asia and the northern vole is also restricted to these regions in the tundra and high steppe. The wolverine (a rather bear-like mustelid) occurs today in the mountain forests of Scandinavia and North America.

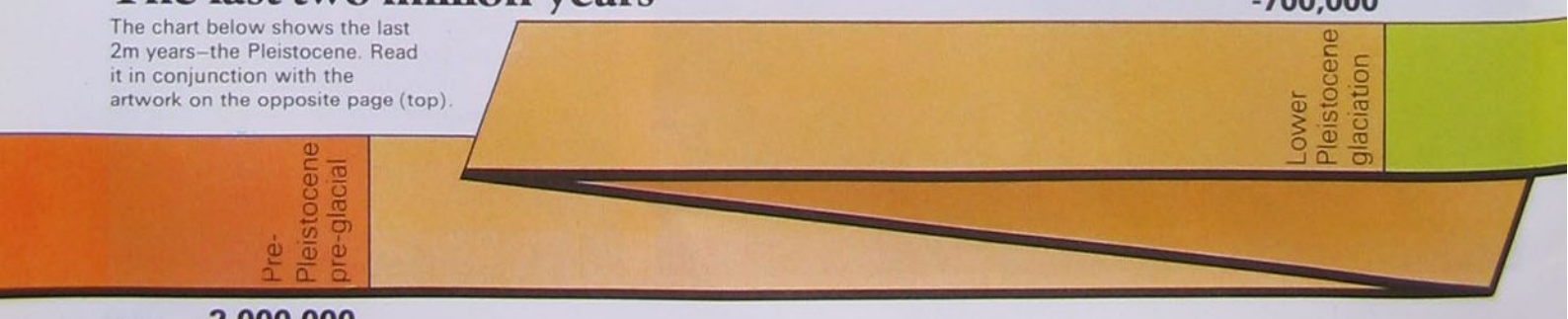
Like the wolverine, northern vole and steppe pika, the arctic fox, and the varying and the Norway lemmings also seem to have disappeared from Britain at the end of the last

Ice Age. The lemmings probably suffered from loss of tundra with the consequent reduction of sedges and willows, their main food plants. The Norway lemming now occurs in the mountains and tundra regions of Scandinavia while the varying lemming is restricted in Europe to the tundra of Russia. In previous warmer periods, the root vole was apparently one of the commonest small mammals in Britain. Unlike the lemmings, it seems to have persisted into the post-glacial age since remains have been found in the Scilly Isles, dating from as late as the Bronze Age. Though no longer present in Britain, it occurs across much of Europe.

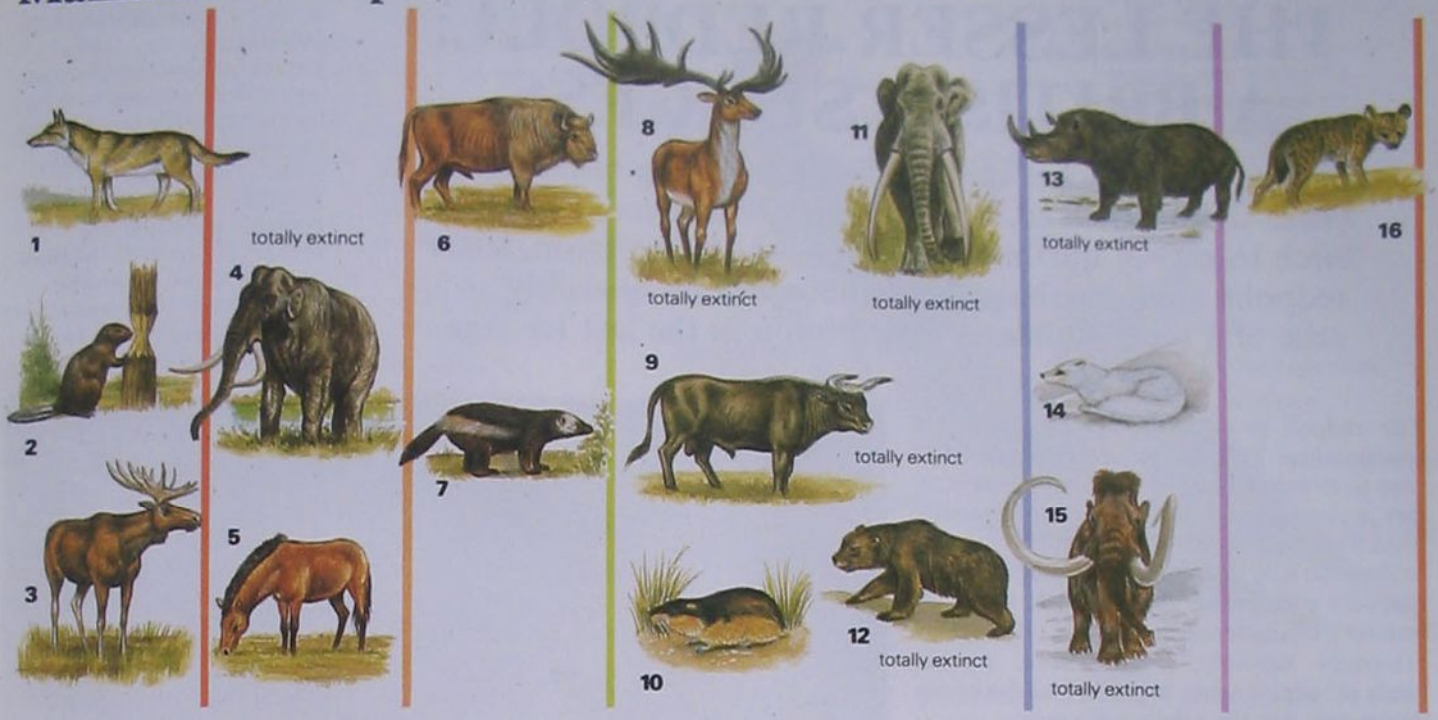
Warmer times Tundra conditions came to a sudden end about 10,300 years ago, when the

The last two million years

The chart below shows the last 2m years–the Pleistocene. Read it in conjunction with the artwork on the opposite page (top).



Mammals of the past



climate changed from glacial to temperate very quickly. This marked the end of the last Ice Age, and the beginning of our present warm period.

In early post-glacial times, birch woodland spread once more. Forest dwellers such as the elk became more common as well as such mammals as the beaver, wild boar and aurochs. The large areas of swamp and marshy lakes probably benefited the elk, which in summer feeds extensively on semi-aquatic and aquatic vegetation. However, it does not seem to have survived long into the post-glacial, possibly because of hunting by Mesolithic man. Some authorities suggest that the elk survived until the Iron Age (about 2500 years ago) when pine forests were replaced by swamps, with the subsequent loss of their winter source of food.

Other mammals found in Britain in the post-glacial birchwoods included the pine marten, badger, beaver, hedgehog, hare, roe deer, red deer, wild boar and aurochs. Most still exist in Britain, although the aurochs became extinct in the Bronze Age. This species was the forerunner of domestic cattle and used to occur in deciduous woodland across much of Europe and Western Asia. Its decline was mainly due to persecution by man.

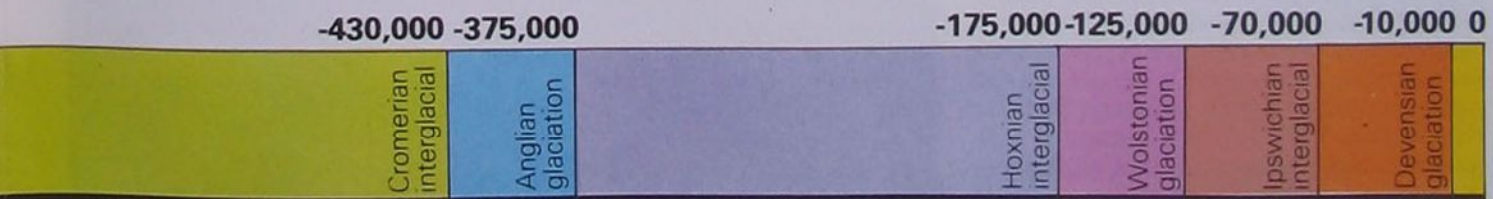
The first large scale woodland clearances were made by Neolithic man as he started to cultivate the land, particularly those areas with lighter soils. Mammals such as wolf, brown bear, lynx, wild boar, aurochs and elk were all greatly affected by the progressive decline in the deciduous woodlands. The extensive forests on low-lying clay soils (in areas such as the Weald) remained a refuge for wolf, bear and boar until Elizabethan times, when the first serious attempts at cultivation were made.

One such species of the forest, the wild boar, still occurs across much of Europe, though it has a much smaller range than before due to hunting pressure and the destruction of woodlands. In Britain it became extinct in the 17th century for these reasons, although it was close to its northern limit anyway, having never occurred further north than southern Scandinavia.

The lynx, bear and in particular wolf, all prey on domesticated animals, which has resulted in heavy persecution throughout history. The lynx survived only into Neolithic or early historic times. The brown bear probably became extinct in Britain in the early middle ages, and the wolf died out in the 1740s. Since that date no other British mammal has become extinct, though several are now threatened.

Above: All the mammals shown here are now extinct in the British Isles and some–as indicated–are totally extinct in the world. The figures in brackets below show approximately how many years ago they became extinct here.

1 Wolf (240 years ago).
2 European beaver (795-400).
3 Elk (2000-1600).
4 Southern elephant (500,000).
5 Wild horse (10,000).
6 Bison (10,000).
7 Wolverine (10,000).
8 Giant deer or Irish elk (10,000).
9 Aurochs (3600-1000).
10 Lemming (10,000).
11 Straight-tusked elephant (70,000).
12 Cave bear (175,000).
13 Woolly rhinoceros (25,000).
14 Arctic fox (10,000).
15 Woolly mammoth (10,000).
16 Spotted hyena (10,000).



The Pleistocene Epoch lasted two million years, but of the mammals shown above only the elk, European beaver and wolf were present earlier than this. The majority of the mammals shown appeared in the last 700,000 years–proportionately a very short time ago in terms of the evolution of the British Isles. The last Ice Age ended just 10,000 years ago and man gradually began to settle the land.

Bronze Age–3500-2500
Iron Age–2500-2000
Roman Occupation–2000-1600
–all in terms of years ago.

THE LESSER REDPOLL: A BRITISH SUCCESS

Redpolls are finches that specialise in eating birch seeds. These small, streaked, brown birds are associated with the birch forests of northern latitudes. As an exception, lesser redpolls are flourishing throughout Britain, possibly as a relic of a more southerly distribution in the last Ice Age.

Below: A lesser redpoll at its nest in a pine tree. While some of the habitat changes wrought by man seem to be harmful to many bird species, the establishment of large areas of new forestry plantations of conifers has certainly benefited the redpoll. Its increase in range appears to be continuing, and the birds have recently begun colonizing the North Sea coasts of the Continent.

The redpoll is one of those infuriatingly sparrow-like, little brown streaky birds that tend to be overlooked by most people. It is, in fact, a close relative of the linnet and in many ways it is a smaller version of that species. But to describe it in this way overlooks one of the redpoll's even more 'difficult' (to the bird-watcher) characteristics, for its plumage is extremely variable. Furthermore, several kinds of redpoll occur in the British Isles; one is common but the others are rarities.

Five main forms Redpolls are divided into two species, both of which breed all around the northern parts of the world–North America, northern Europe and northern Asia. Of the two species, the Arctic redpoll, which has a largely white rump and a shortish, deep bill, occupies the northernmost part of this circumpolar range. It occurs in two forms, known as Hornemann's and Cove's redpolls.

At lower latitudes, the common redpoll, with a brown streaked rump and longer fine bill, has a number of forms. Two of these–the mealy redpoll, which breeds in North America, northern Europe and Siberia, and the Greenland redpoll, which breeds in Greenland and on Baffin Island–occur in Britain as irregular migrants. The form of the common redpoll that breeds in Britain is known as the lesser redpoll and it also breeds in central European mountain regions.

Added to this confusion is the variability of plumage within each form; some of this stems from interbreeding, where two forms overlap. Even at the species level, Arctic and common redpolls interbreed where their ranges overlap to produce hybrids of highly variable character.

The British form Our own lesser redpoll is, however, less variable than other races. It is basically a brown bird, streaked with black, with paler under-tail feathers and with a forked tail. A good view of an adult reveals its diagnostic features–a crimson forehead and a black chin and, in the adult male, a breast and rump suffused with pink. In young birds the chin patch is less noticeable, since it is slaty rather than black. In its general appearance the redpoll is thus rather like a small (12cm/4¾in) version of the linnet, and this resemblance also extends to the birds' flight. This is undulating, in typical finch manner, but is more buoyant than the flight of relatives like the chaffinch and greenfinch. Redpolls also tend to fly higher than most finches, but the best distinguishing feature of a flying redpoll is its call, a metallic and rather loud 'chu chu chu chu chu . . .' which is quite unlike the rapid twittering of the linnet.

Trilling song During display, the male redpoll produces a short rippling trill which is its song, but in display flights both the song and the flight call may alternate. In the display flight a male twists and loops with slow and exaggerated wing beats, like the more familiar song flight of the greenfinch. Sometimes, a small group of males sing and display together, while on other occasions a male delivers his trilling song from a perch or while flying along normally.

Redpoll distribution

The population of lesser redpolls in Britain and Ireland has increased so rapidly in recent years that even the latest research on their distribution is already out of date. Data collected by the British Trust for Ornithology showed a four-fold increase between 1964 and 1974, an increase which may be continuing today. They now breed in most parts of Britain and Ireland.

Display flights are a prelude to nesting, and the displays by several males together usually imply that a small loose colony is about to breed in the vicinity. Social nesting is by no means the rule, however, and many pairs may reproduce in comparative isolation.

Seed diet The food brought to the chicks consists mainly of small caterpillars and other insect larvae. Apart from this, however, the redpoll is predominantly vegetarian, specialising in seeds, notably those of birch, but it also eats the flowers and seeds of sallow, the seeds of alder and grasses and the small seeds of many composites. When feeding, redpolls display great agility and they can cling to the thin stems of dandelions or hang beneath the fruits of birch and alder in order to reach the seeds.

Modern success In Britain, the redpoll's chief preference is birch seed, and in the early part of this century it was to be found mainly in the birch woods of the north and west. High densities are still found in these areas, but the birds' adaptability has enabled them to breed in scrub and along tree-fringed streams in more southerly areas. More significant, however, has been the redpoll's ability to colonize our ever-increasing areas of young conifer plantations. Nests are built between 2m and 4m (6-13ft) above the ground, and plantations with trees up to 6m (20ft) tall have proved highly acceptable to redpolls. The creation of these habitats has led to a population explosion of redpolls in Britain since the 1950s.

Redpoll eruptions The problem with specialisation on a diet of tree seeds is that the annual seed crop undergoes considerable variation, often with good and bad years alternating. This is reflected in large fluctuations in the breeding populations of the birds, so that an area which may be good for redpolls in one year may support very few the next. This variation in the food supplies has a further consequence, for when bird numbers have become high and the seed crop suddenly fails, the birds must move in search of alternative food if they are to survive.

The migration that they undertake is thus an irregular, rather than an annual, occurrence. Many, though not all, of the birds leave Britain for the Continent. This somewhat unpredictable departure is known as an eruption. (An irregular outward migration is called an *eruption*, while an irregular inward migration is called an *irruption*.) Most redpoll eruptions from Britain take the form of overwintering in the Netherlands, Denmark, Belgium and Germany, but on rare occasions–presumably when food supplies even in these countries have been scarce–a few redpolls have reached south-western France and even crossed over into Spain. After some of the larger eruptions a few redpolls have remained in Denmark and the Netherlands, and established breeding colonies.

Two redpoll species

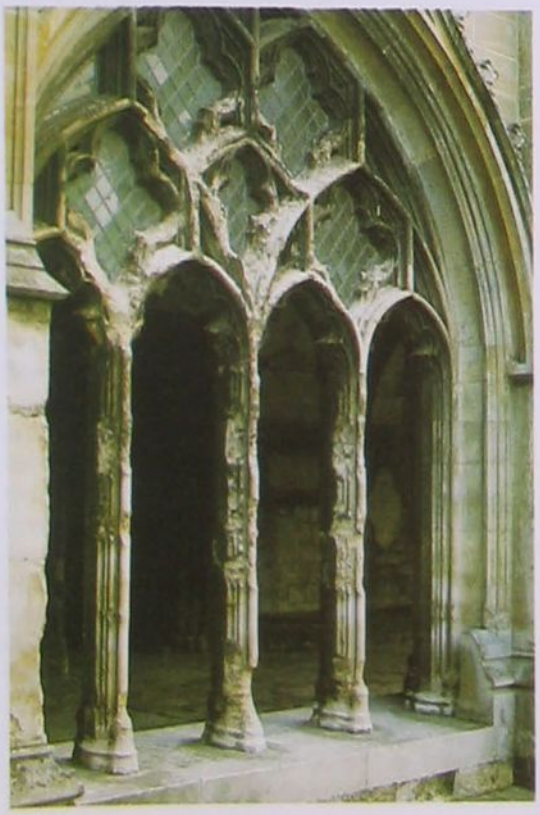
Lesser redpolls form the vast majority of British and Irish redpolls, but the Arctic species occurs here as a vagrant. It is larger, and has a white rump.

Common redpoll (*Acanthis flammea*). Finch of north temperate latitudes. Three forms occur in Britain and Ireland: Greenland redpoll (vagrant), mealy redpoll (vagrant), lesser redpoll (resident, partial migrant). Length 12cm (4¾in).

Arctic redpoll (*Acanthis hornemanni*). Arctic and subarctic replacement of common redpoll. Two of its forms occur in Britain and Ireland, both as vagrants–Hornemann's redpoll and Cove's redpoll. 14cm (5½in).

Left: Lesser redpolls build their nests mainly in May and June, the female undertaking the construction while the male remains nearby.

Below: A male lesser redpoll at the waterside.



POLLUTION–THE LEGACY OF MAN

Man's pollution of the environment by ever-growing mountains of industrial, chemical and organic waste products is a subject of great concern to the world today. Here we look at some of the ways in which pollution affects us and our countryside.

It is very easy to believe that man's pollution of the environment is a modern phenomenon. But a little thought soon reveals that this is not so, for activities associated with hunting, farming and cooking food inevitably lead to 'the destruction of the purity' of land, air or water–a dictionary definition of the word pollution. However, it was not until the formation of developed societies that the local effects caused by small-scale settlements gave

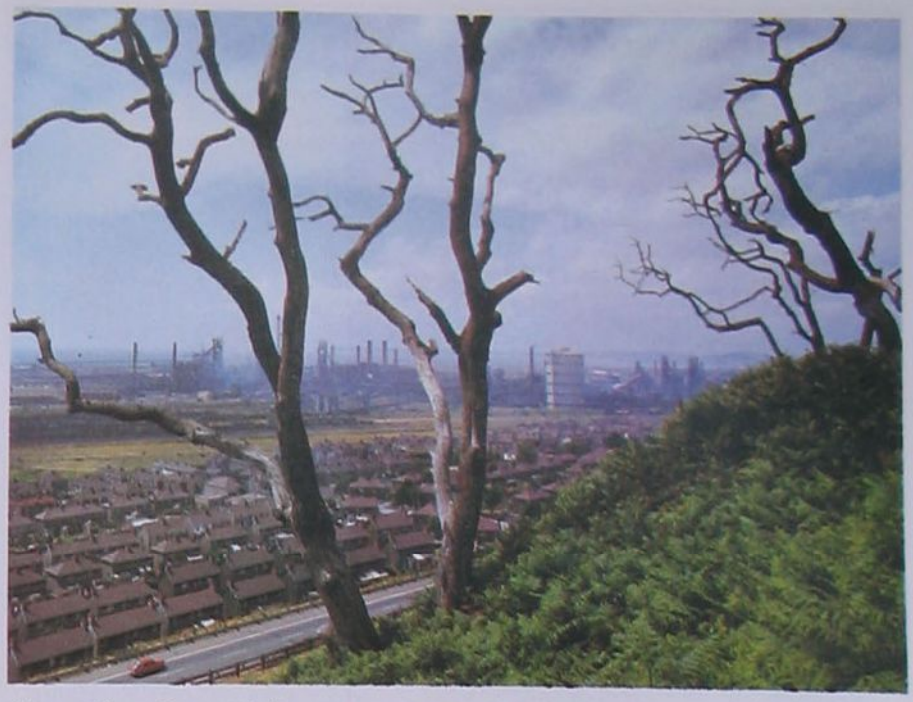
Above: Dust from a cement factory produces a brown haze–air pollution.

Opposite left: Plants and animals are not the only ones affected by pollution. The burning of fossil fuels produces sulphur dioxide which attacks stonework, as here at Canterbury Cathedral.

way to major pollution. Domestic rubbish, sewage and smoke were probably the most common sources.

Smogs, fogs, and dust Smoke as an air pollutant and threat to health only became a serious problem with the onset of industrialisation. By 1950 the uncontrolled consumption in the British Isles of millions of tons of coal and fuel oil had resulted in the annual release of millions of tons of smoke, dust and sulphur dioxide. This was the direct cause, on humid winter days, of the choking oily 'smogs', which were at their worst in London. Here in 1952 smog was the direct cause of the deaths of some 4000 people. At particular risk were those with respiratory complaints. Animals suffered too–in 1957 cattle at the Smithfield Show died during a smog. Legislation was introduced in 1964 to control smoke pollution in Britain, and the combination of smoke-free zones and higher standards for factory chimney emissions has produced the cleaner cities of today.

Nevertheless, pollution from smoke still occurs, and there are some insects and plants which readily reveal this without recourse to complicated chemical analysis. In general, gaseous pollutants are more toxic to plants, attacking the tissues of leaf and frond, while dust-borne chemicals are hazardous to animals, which may ingest them with food or inhale them, so clogging lungs or gills. For instance, lichen–that strange amalgam of an alga and a fungus–has been shown to be extremely sensitive to air pollution and trained observers are able to assess conditions through the presence, absence or relative abundance of key indicator species. In towns the lichen flora is always impoverished compared with equivalent unpolluted countryside of similar climate. Even on the west coast of Britain, where trees and walls grow fuzzy coats in the prevailing clean Atlantic air, towns and factories cast shadows where lichens find it hard to thrive.



Above: The effects of air pollution at the Port Talbot steel works (in South Wales)–the trees have all died.

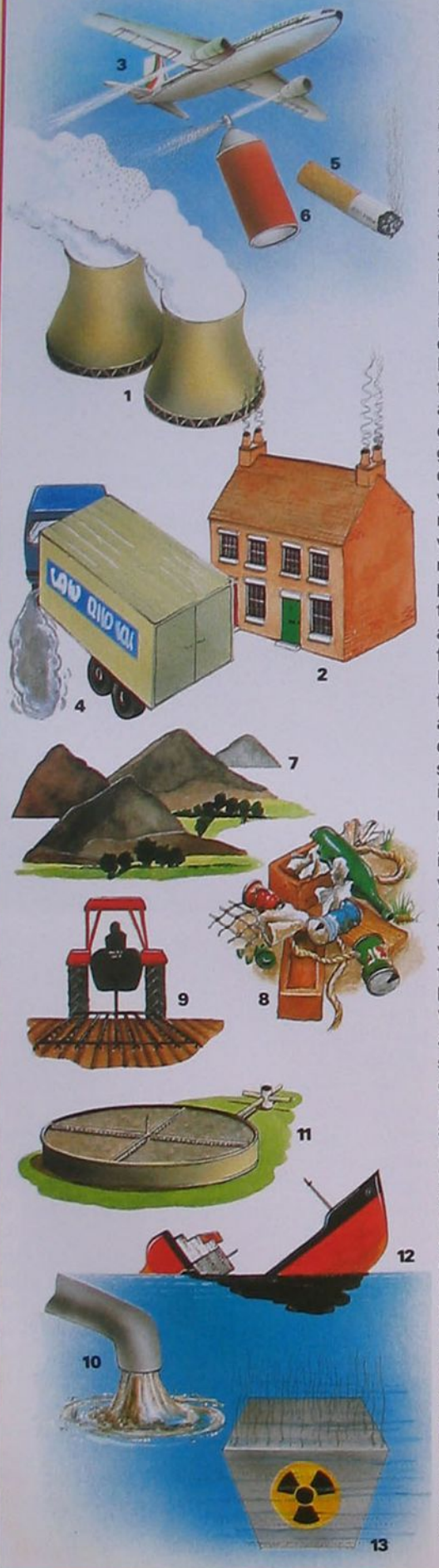
Right: By contrast, in an unpolluted environment such as that of Wistman's Wood in Devon, ferns, mosses, lichens and liverworts flourish in luxuriant profusion.

Below: Dust has spread like a grey shroud over the land and trees adjacent to this factory complex.

Dust from cars and chimneys has caused subtle changes in animals which live in dirty areas. The peppered moth is the classic indicator of urban grime. In its 'normal' form the moth is light coloured, with dark speckling–excellent camouflage on the trunks of country trees. But in towns, where tree trunks are much darker, birds find these light moths easy pickings. However, a dark variety of this moth is better hidden under these conditions and is consequently far more numerous in towns than in the countryside. This, called industrial melanism, has also been observed in other insect species, such as ladybirds.

Sulphur dioxide The combustion of coal and oil releases many chemicals into the atmosphere. Sulphur dioxide, which is believed to have been the most dangerous component of the 1950s smog, still belches from the chimneys of homes and factories alike. For, despite the superficial improve-

Pollution sources



Where does pollution come from? Today, in our highly industrialised society, there are many sources–most resulting from the activities of man.

Air pollution One problem causing growing concern on a world-wide basis is that of acid rain. This is caused by increasing amounts of sulphur dioxide entering the atmosphere when fossil fuels such as coal and oil are burnt in factories (**1**) and households (**2**). Rain acidity is also increased by nitrogen oxides–produced by the very high temperatures created in the combustion of fossil fuels and also emitted from vehicle exhausts (**3**). Vehicle exhaust gases (**4**) also contain carbon monoxide and lead, which may accumulate along roadside verges and interfere with food chains. On a very much more local scale, air pollution is also caused by the smoke from cigarettes (**5**) and the concentrated sprays from aerosol cans (**6**).

Land pollution can take the form of dereliction–the huge areas laid waste by open-cast coal and clay mining (**7**) and stone quarrying, and by the indiscriminate dumping of metal and plastic waste items (**8**). A more serious problem is that of the pesticides and weedkillers used on farmland (**9**) to kill insects, weeds and fungi. These may interfere with other living things than the ones they are meant to kill.

Water can be polluted from an enormous variety of sources–factory and mining effluent (**10**) can either poison fish outright, or block sunlight from the water, so making it impossible for water plants or animals to survive. The millions of microscopic bacteria in sewage (**11**) extract dissolved oxygen from the water–again making the water uninhabitable for wildlife. Oil spillage (**12**) is an extremely well known form of pollution which kills thousands of seabirds and sea mammals each year. Grave potential danger also lies in the dumping of nuclear waste (**13**) in the sea–leakage could cause enormous problems.

ments caused by the Clean Air Acts, millions of tons of this gas are released each year. Tall factory chimneys make dispersal easier and the gases become mixed with the atmosphere–a practical application of the saying that 'the solution to pollution is dilution'. But sadly it is also true that 'what goes up must come down'. What goes up as hot flue gases in Britain comes down as dilute sulphuric acid rain in Scandinavia. This problem is not new and has been well documented for 20 years, but what has changed is the increased scale of damage, not only in Sweden and Germany but also in Canada, Scotland and elsewhere. There is now mounting pressure for new legislation within the EEC to reduce sulphur dioxide emissions to protect upland lakes and forests.

The example of acid rain clearly shows the way in which chemicals released into the environment in one form may reappear elsewhere in a different guise. This exposes a major flaw in the dilution approach to pollution control for, whereas the volumes of the atmosphere and of the sea are vast in comparison to the quantities of chemicals released into them, they are finite, and mixing within them is imperfect. In global terms, the small volumes of sulphur dioxide released in Britain may have a profound effect elsewhere through the agency of ill-defined physical systems.

Industrial spoil The combustion processes

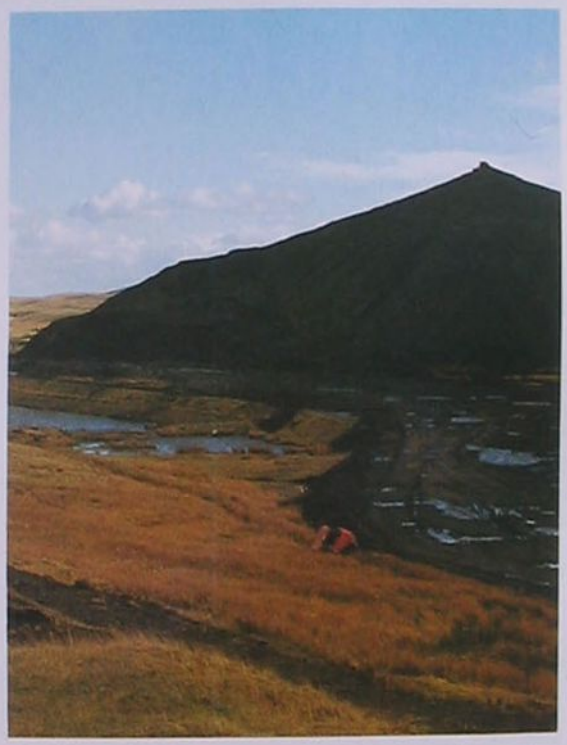
which generate large quantities of atmospheric pollutants also generate mountains of ash and clinker. These waste products may be of little or low toxicity, but they do create local pollution by the sheer volume of material. On a restricted scale, communities of animals and plants may be completely destroyed by spoil dumping, but fortunately such gross pollution is seldom accompanied by problems of acute toxicity. However, in some parts of Britain and Europe, where the industrial revolution glowed most fiercely, the cinders of two centuries may still blight the landscape.

The lower Swansea Valley is a good example of the scale upon which uncontrolled dumping may occur. In the early 1960s 10 million tons of slag, a disrupted drainage system, decaying buildings and abandoned trackways littered the 5sq km (two square miles) of the Lower Valley. More seriously, the slag itself, formed during the smelting of

Above: The spoil and waste heaps that result from coal mining create an eyesore in the countryside that can take many years to heal. Heal it eventually may, however, as witnessed by this natural invasion of silver birches and pines on an old colliery tip in the Forest of Dean.

Right: A spoil heap from a coal mine in South Wales–nothing green grows here at all. It will be many years before even the coarsest grass begins to clothe this heap, unless man steps in to add topsoil and plant trees.

Left: Derelict cars dumped in a wood–an unsightly 20th century problem.



Above: A dead mute swan with its beak inextricably entangled in a discarded fishing line, which prevented feeding. Swans also die from ingesting lead fishing weights–one estimate puts deaths at 3000 swans each year. There is now pressure on the fishing community to use non-toxic weights.

ores containing copper, zinc, lead and arsenic, retained extremely high concentrations of these and other toxic heavy metals and remained bare of vegetation. A detailed scientific appraisal of the problem of the Lower Swansea Valley was followed by practical trials to identify the best techniques for revegetating and stabilising the tips. Today, while the problem has not totally been resolved, a combination of topsoiling, landscaping and tree planting has improved the visual amenity. Some progress has also been made in the use of metal-tolerant strains of grass.

Superficially all this might be considered a success and, indeed, a variety of wild creatures, including the kestrel, have been attracted back into the Lower Valley–but the toxic wastes which formed the slag heaps have not been destroyed but merely disguised or used for infill. The current approach to pollution control at places like Avonmouth, where zinc smelting still con tinues, is to prevent rather than cure, although inevitably this can never succeed completely, for once toxic elements have been unlocked from geological strata they pose a long-term problem.

Heavy metal pollution The heavy metals, a loosely defined group of elements which include copper, zinc, lead, mercury, nickel, cobalt, tin and some 30 others, played a vital part in the industrial revolution. Each heavy metal has specific metallurgical properties and as machinery and industrial processes became more advanced, increasing quantities of these elements were refined. The Lower Swansea Valley was an important early centre for smelting processes and the scale of pollution which occurred there was not often repeated.

The toxicity of heavy metals to living organisms is due to a combination of an intrinsic ability to bind with living cells and the metabolic disruption which they may cause in doing so. Indeed, although some, such as copper, iron and cobalt, are essential to life in small quantities, this particular affinity for cell membranes and proteins means that the heavy metals form a group of particularly dangerous pollutants. For, combined with their high toxicity, they are widely dispersed in the environment. Contamination can occur at the point at which the crude ore is mined, the site of smelting and refining the metal, the point of consumption and at the subsequent disposal of the waste metal.

Each of the heavy metals has particular chemical and biological characteristics which are not possible to catalogue here. However, these elements are likely to cause increasing problems at the present rate of their release into the environment. Recent fatalities of hundreds of wading birds in the Mersey have been attributed to the accumulating toxic cocktail of heavy metals discharged from homes and factories. The fact that the exact mechanism and details of the problem are not known is a further cause for concern.

Lead is one heavy metal which might be a less serious pollutant in the foreseeable future. Already the use of lead in paint, toys and water pipes is restricted and recently the British Government announced that it would promote the introduction of lead-free petrol within a few years. Lead compounds are added to petrol to enable car engines to work more smoothly on lower grade fuel. However, evidence suggests that lead in dust poses a direct hazard. It is well known that high lead levels can cause hyperactivity and other behavioural disturbances, particularly in children. Some experts now claim that the levels of lead in city dust, resulting from car exhaust fumes, are already high enough to account for toxicity symptoms observed in some children. It remains to be seen if the Government's announced good intentions are speedily put into effect.

INSECTS AND MAN

The relationship between man and insects is one of wariness –a strange situation for there are as many benefits to be gained from insects as there are discomforts.

It is conventional to classify insects as helpful or harmful when discussing their relationships with man, but it is often forgotten that the majority of insects have no obvious connection with man at all. This is not to say that there is no link of any kind. In ecological terms nothing lives alone, and if you follow insect food chains you find some interesting, if tenuous, connections with our own activities. Take dragonflies hawking up and down a stream; they keep well out of our way, but serve us well by keeping down the mosquito population. On the other hand, the dragonfly is one of the hosts of a parasitic flatworm affecting chickens and their egg-production.

This is a case where one insect species is both good and bad, but there are many other insects which all have much stronger and more tangible human connections.

Bees and other allies The honey bee is at or near the top of every list of useful insects, qualifying on several counts. The honey we take from it in the UK, amounting to some five and a half million pounds a year, is obviously very important–and so is the beeswax we use for making polishes–but these materials are really far less vital than the bee's role in pollinating our flowers and crops. In their relentless search for nectar and pollen, the bees ensure that flowers are pollinated and have a chance of setting seed.

Bee stings can be dangerous–a few people are especially sensitive to them and react badly, although fatalities are rare–but there is also evidence that the venom is useful in treating rheumatic conditions.

Green lacewings (along with ladybirds) are another group of man's allies because of the war they wage against greenfly and other aphids. You can use them for small-scale biological control in the garden by collecting the adults and larvae and putting them on aphid-infested plants, but large-scale rearing of lacewings for this purpose does not seem feasible.

Nature's dustmen An entire army of scavengers is employed in clearing up the dead bodies and the excrement of other animals, making the countryside more attractive as well as releasing nutrients for re-use by the

Left: Modern hygiene has fortunately reduced the chances of coming across a bed bug in the house.

Right: A bumble bee's most important function is the pollinating of flowers–Darwin was able to prove that the amount of clover seed produced in a field depends on the strength of the bumble bee population. Unlike honey bees, their small annual colonies do not make collection of their honey an economic proposition for us.

Left: A 7-spot ladybird feeding on aphids. Ladybirds are allies of man because they prey on such pests. Their appetites can be immense, a single large ladybird larva eating as many as 100 aphids in a day. Not surprisingly, in some parts of the world they are used for the biological control of pests. In North America, for instance, the Australian ladybird *Rodolia cardinalia* was introduced to control a pest scale insect.

plant community. They are not driven by an innate desire to tidy up the land, of course; the corpses and excrement are food for these insects and their young.

The burying or sexton beetles are well-known for their disposal of small corpses. Working in pairs, they bury the corpse by digging soil from underneath it. The female lays her eggs on or near the corpse so that the young have a food supply of flesh and maggots.

Crop pests Both on the farm and in the garden crop pests are among the most familiar of the harmful insects. The damage done by the caterpillars of the large white butterfly is all too familiar to the gardener, and anyone who raises brassicas from seed will also know the infamous flea beetles, which chew small neat holes in the seedling leaves. Leatherjackets do equally serious damage below ground.

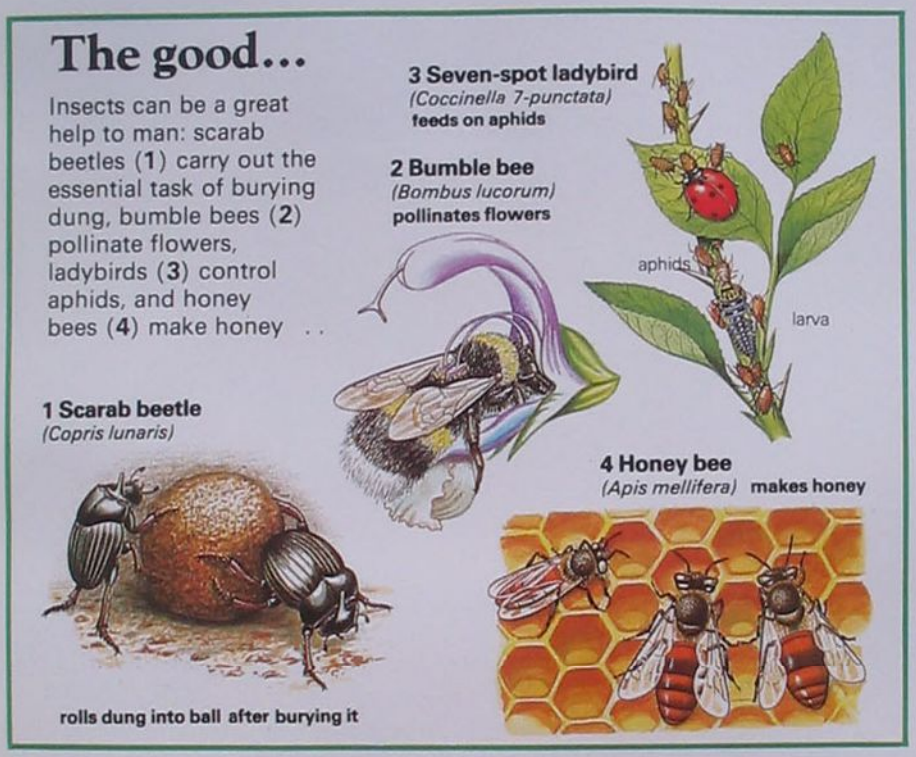
Aphids, generally known as blackfly and greenfly, are sap-sucking bugs that play havoc with many crops. The mechanical damage caused by thousands of tiny needle-like probosces projecting into the plants and withdrawing sap causes much distortion of growth, but even more serious are the numerous virus diseases (sugar beet yellow and potato mosaic, for instance) carried by the aphids.

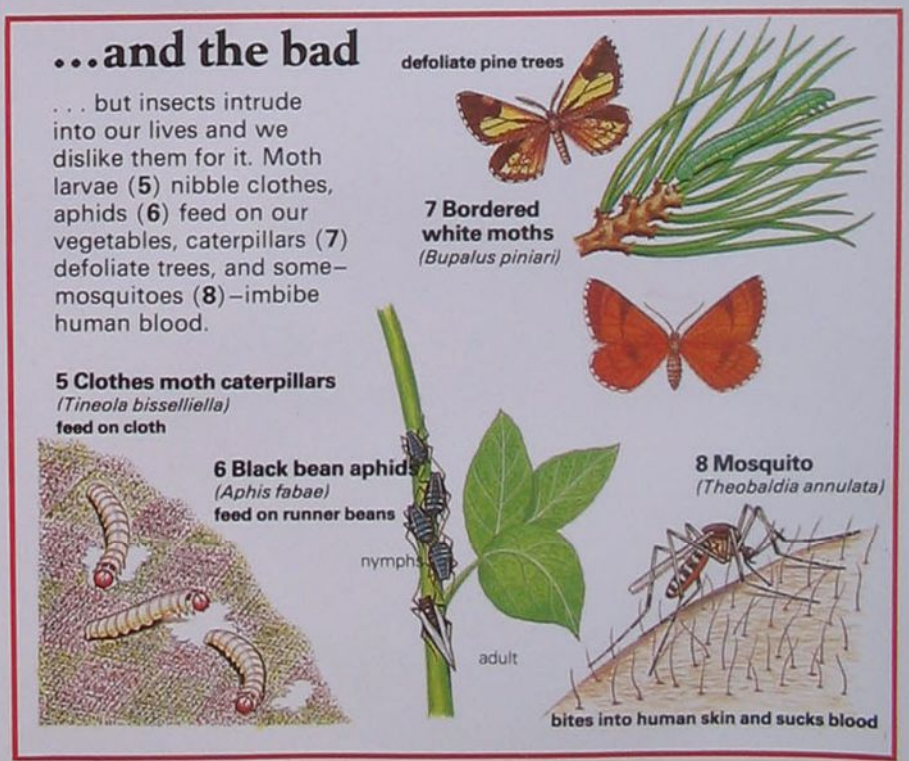
Insect larvae occur in many fruit crops, notably raspberries and apples. Several attack apples, but the most familiar is the grub of the codlin moth, a small pink caterpillar.

Trouble in the store Our problems with insects do not stop when the crops have been harvested. Many pests continue to eat the produce in the store, and they are joined by a large number of specialists–the stored product pests. On a global scale it has been estimated that about one quarter of the world's food supplies are destroyed at, or after, harvest by pests. Most damage occurs in tropical areas, but many of the tropical insects have found conditions in our granaries and flour mills to their liking and established themselves here long ago.

The grain weevil is one of the most serious grain destroyers. Both adults and larvae feed on grain, and with each female laying up to 200 eggs it is easy to see why infestations build up so easily. The Mediterranean flour moth is another serious pest, causing losses in flour mills.

Forest pests All parts of trees are attacked by various kinds of insects. One of the worst





offenders in Britain is the bordered white moth whose larvae, known as pine loopers, strip the needles from large areas of plantation pine trees. The insect that has caused the most dramatic impact on our countryside in recent years, however, is the elm bark beetle–carrier of the Dutch elm disease.

Pests in the house The most serious household pests are the timber feeders that attack the very fabric of the house. Several species of beetles are involved here, with common woodworm being the most abundant. The woodworm is, of course, the larva which tunnels unseen through rafters, floorboards and furniture. The adult, a small brown bullet-shaped beetle, is commonly known as the furniture beetle. It has been estimated that some 75% of buildings harbour this pest which, when present in large numbers, can reduce sound timber to dust within a few years.

Carpets, clothes and other fabrics suffer from the attentions of numerous pests, including carpet beetles, fur beetles and clothes moths. As far as clothes moths are concerned, it is the larvae that do the damage. They are among the few lepidopterous larvae that feed on animal material–hair, wool and feathers. (Their natural homes are the nests of birds and rodents, where they find plenty of natural fibres.)

Biters of man The insects that attack our own bodies are the most unpleasant of all the pests, and most abundant are the various kinds of flies. Mosquitoes are well-known

Above: Honey bees produce, on average, about five and a half million jars of honey a year in the UK.

Right: The housefly is an unpopular insect since it can deposit dangerous germs on food.

Below: A burying beetle beginning the daunting task of burying a corpse.

blood-suckers, the females generally needing a meal of blood before they can lay their eggs. Anti-coagulants are injected into the wound while the insect feeds, and these can cause symptoms ranging from mild irritation to severe blistering. Mosquitoes capable of carrying disease still exist here and could cause problems if malaria ever returned to Britain.

Potentially less serious, but even more of a nuisance, are the millions of tiny midges that tickle and bite us, especially in upland areas. Other biters–more correctly described as piercers and suckers–are the horseflies and insidious clegs. The latter fly silently and land on us unnoticed–until the sharp beak goes in for a meal.

Even in the house man is not free from the biters, although modern hygiene has greatly reduced the numbers of fleas, lice and bed bugs. The human flea is now rare, but cat and dog fleas can still be a problem in houses with pets. Typhus fever, dog tapeworms and myxomatosis are all carried by fleas.

Our effect on insects Clearly insects have had a great effect on man, but what of man's effect on insects? Leaving aside the direct effect of the pesticides which we spray on them by the ton, the most important effect has been through changes to the insect's environment, particularly the loss of habitats.

WHITER THAN WHITE: ALBINO ANIMALS

The colours of animals are the result of pigments contained within the skin, fur or feathers. However, occasional genetic imbalances cause a complete lack of pigmentation, resulting in pure white animals with pink eyes–albinos. At the other extreme are melanistic–all black–animals.

Albino animals are really quite scarce, yet they are familiar to us simply because they are so strikingly conspicuous. Less obvious colour variants pass almost unnoticed, even though they may be much more common. Albino animals lack the normal coloured pigments; the opposite extreme to albinism is melanism, where the animal has so much black pigment (called melanin) that it is pure glossy black all over.

Out of the ordinary Albinos are conspicuous not only because white stands out but also because they are so very different from the normally coloured animal. Partial albinism is found among newts, where it is often associated with neoteny (a failure to grow up and become fully mature). The axolotls, often kept as pets in Britain, are giant newts from America and the commonest type seen in aquaria is the white form. It too is neotenous and hardly ever changes out of its larval form.

In frogs the situation is a little complicated because, although albinos occur and are lacking in melanin pigment in the skin, they are not white. The albino animal is a golden yellow colour due to the effect of other

Above: An albino peacock, displaying his fine feathers. In the days when it was fashionable for naturalists to shoot birds for their collections, albinos were particularly prized items and often sold for high prices. Even today many museums have extensive collections of stuffed albinos in their cabinets, and glass cases featuring white pheasants, larks, blackbirds, swallows and many others.
It is because of this bird collecting mania that we tend to think of albinos mainly in terms of birds. In fact albinism occurs just as frequently in other animal groups, perhaps the most extraordinary example being an albino grass snake that lived at London Zoo: it was ivory white with semi-transparent belly scales.

elements in the skin, and it has red eyes (in contrast to the normal black pupil and shiny gold iris, or pink eyes of an albino). Some researchers believe that this condition occurs more often in females than males and is commonest in Scotland. The spawn of albino frogs lacks black pigment, as do the tadpoles. Albino toads have been recorded only rarely in Britain. Albino snakes and slow-worms are also rare in this country. Albinos also occur among fish and mammals. About one in 20,000 humans is an albino, too.

Full and partial albinism represents abnormal states, but some animals are normally white, swans being the most obvious example. Several other animals go white in winter (for example, stoat, mountain hare and ptarmigan); it is an adaptation to provide camouflage against white snow.

Elusive animals Although so conspicuous, albinos are comparatively rarely seen. This is partly due to the fact that, for genetic reasons, they are much rarer than normal types; but another reason is that if we can see them, so too can any predators, and they soon get eaten. Their very conspicuousness means that they are more likely to be removed from the population, making them rarer still.

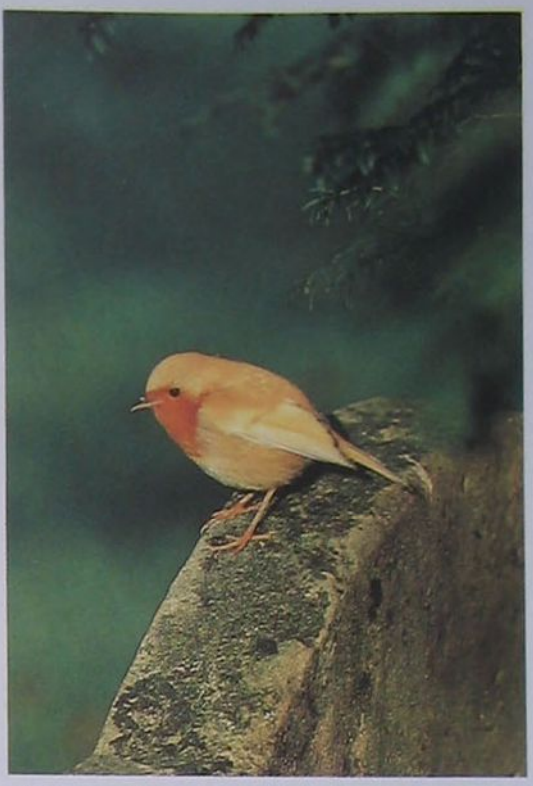
Pure albinos suffer another disadvantage in this respect: their pink eyes do not function as well as normal eyes in daylight, so it is probably less easy for them to see approaching danger or hunt food. Thus we might expect albinos to be more frequent among those animals that are least affected by predators. To some extent this is the case: a ghostly white wood mouse or bank vole, for example, would soon be snapped up by an owl, being easily seen in the dark; by contrast, a mole could be tartan with luminous stripes, so long as it stayed safely in its underground tunnels. In fact, while pale variants are exceedingly scarce in wood mice and bank voles, white moles are comparatively common (though still less than one in a thousand). Grey and apricot coloured moles are also found. Animals that live all their life in the pitch dark of caves can similarly be white with impunity.

Above: A partially albino blackbird, which is quite a common occurrence. It is likely that at least some of the descendants of this bird will inherit similar abnormal white patches on their bodies. People often recognise individual partially albino blackbirds that visit their gardens–they become welcome and familiar visitors and are sometimes even given names.

Below: A pure albino rabbit (left) and an almost pure albino hedgehog (right), both with the typical pink eyes associated with albinism. Some partial albino animals have enough dark pigment to produce normal dark eyes and nose, but their fur or feathers remain pure white.

Very occasionally, when man steps in, whiteness may actually save an animal from destruction. White fallow deer for example, are often seen in deer parks, retained because of their interest and striking appearance. In the wild, these would tend to give away the presence of a herd. The frequency of albinism does not depend on predation levels. It is genetically controlled so its incidence is affected by genes and by the number of offspring that are produced.

Genetic controls Albino animals have a malfunction in the biochemical mechanism responsible for the production of melanin in the body. There is a blockage in the chain of chemical events which should lead to the formation of black pigment, so it is not produced. The fur or feathers then contain no black or brown colours. Usually this results in their being white due to the presence of minute air bubbles which scatter light and cause a white appearance (just like shaking up a half-full bottle of water: it starts off transparent, but soon looks milky due to the millions of tiny bubbles, although there is no white pig-



ment present).

Failure of melanin production in the skin leaves it looking white or, more often, pink. Full albinos have pink noses and pink soles to their feet–parts of the body which are normally black of dark brown. This is because the redness of tiny blood vessels shows through. For the same reason, a true albino has pink eyes: there is no dark pigment to mask the tiny blood vessels in the retina and so they are visible.

Recessive genes Albinism can be inherited. The gene for albinism is a 'recessive' one, meaning that its effects are masked by dominant ones. Only where both parents contribute the albino gene will any of their offspring be albinos.

In effect this means that the gene, though present, is rarely visibly expressed. However, breeding between close relatives, such as cousins, greatly increases the chances of an animal inheriting the gene from both its parents, so in social animals like badgers or perhaps species that are confined to small areas, inbreeding causes a higher than usual incidence of albinism in particular localities. Often this continues for many generations. Some badger colonies, for example, almost always have pale, if not albino, members.

Actually the situation is not quite so simple because a whole series of genes helps to regulate the amount of melanin produced. The albino gene can stop it totally and cause pure albinism, but the other genes can control the degree of whiteness. It is therefore quite common to find partial albinos where there is enough dark pigment to produce normal black eyes and a dark nose, while the fur or feathers are still white. This happens in hedgehogs and deer, for example: the animal looks like a ghost of its normal self. Genes can be mixed almost as finely as an artist mixes paint, and with similar results. With domestic species, animal breeders can control precisely which animals mate and therefore what genes are passed on to their offspring. Cats, mice, guinea pigs, even goldfishes can be bred for a greater or lesser degree of albinism to produce interesting new colour variants. White doves and white mice are just two examples of pure whiteness being encouraged. The mice frequently include full albinos with pink eyes; whereas, because pink-eyed doves look peculiar, it is partial albinism that is fostered so as to produce normal eyes and white plumage. They are still far removed from their normal coloured ancestor, the rock dove, with which they can nevertheless still interbreed.

Above: A rare albino male slow-worm with a normal individual; a partially albino robin (right) and (below) an albino among other oystercatchers. Albinism can result from the action of a single gene. This is why some parts of the country are well known for a higher than usual incidence of albinos in particular species. For example, albino grey squirrels are commoner in Sussex and Surrey than elsewhere because the albino gene is passed down generations of local squirrels. Similarly, the gene for melanism in grey squirrels is present in those living in the Bedfordshire area, so black ones are common there but not elsewhere.

The polecat The polecat is an interesting case; it was domesticated long ago to help catch rabbits and the albino form was encouraged in captivity because it was tamer and easier to find in gloomy places. Albino domesticated polecats are called ferrets. Many of these later escaped or were lost down

rabbit holes and took their albino genes back into the wild. When they interbred with the wild-type polecat, which they could easily do of course, being the same species, they caused a great variability in coat colour. Nowadays there are many colonies of free-living polecat ferrets in Britain which exhibit fur colours ranging from albino through yellowish to the almost black characteristic of the ancestral polecat. (Escaped mink have similarly taken exotic coat colour genes with them into the wild and there is great variability among free-living mink populations.)

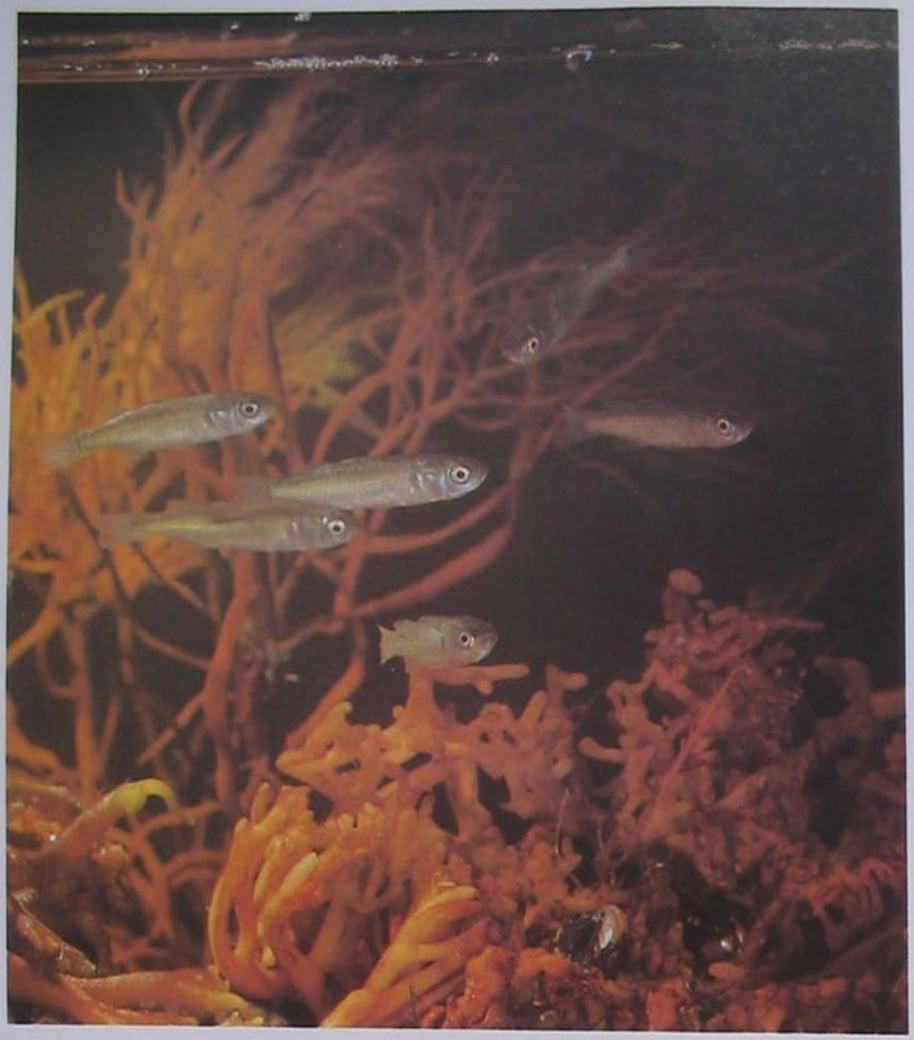
The badger The badger provides an example of a species in which most individuals are similarly coloured, but a few vary from white (albino) to almost totally black, depending on the amount of melanin pigment in the hairs. White badgers tend to become discoloured by the soil in which they live, but their albinistic tendency is revealed by the presence of a pale nose and claws–features that are normally black. Their eyes are pink too and the black facial stripes are invisible. Badgers have been sufficiently well studied for us to know that if only one parent is albino, the offspring will be normally coloured, but one in three of the 'grand-children' will again be albino, the ratio expected from the effects of a recessive gene. It is not always easy to see a badger's colour at night, especially when it has been digging in chalk or the red soils of Somerset.

Partial albinism The term 'partial albino' is sometimes used to describe animals with abnormal patches of white. These variations may, like true albinism, be inherited. Some hedgehogs and blackbirds, for example, have white areas on their body and so do at least some of their descendants. In some species, such as foxes and water voles, the tip of the tail is white in a significant proportion of the population; and this too may be inherited. In parts of Scotland over one third of the water voles have a white cap on top of the head; in other places some of the local shrews have white ear tips. These are normal colour variants within the population, caused by genetic influences, just like the colour of our own eyes or hair. In other cases, the whiteness is caused not by lack of dark pigment (just as in true albinism), but as a result of physical damage to cells in the skin and is not therefore inherited. Minor injury results in localised failure of melanin production. One of the best examples can be seen in adult female common shrews. These often have a patch of white hair on the nape of the neck, the result of being grasped roughly by the male's teeth during mating. Freeze-branding of cattle works in a similar way; a very cold branding iron applied to the skin destroys the melanin synthesising mechanism so that new hairs grow without pigment. The brand mark is then visible as a patch of white fur. These white marks serve to give each animal an identity that we can easily recognise.

Above: A normal and an 'erythristic' badger. In some badgers normal melanin is not produced and the hairs take on a gingery orange colour. These are called erythristic colour variants; a similar apricot colour also sometimes occurs in moles. Albino or partially albino badgers are most often found in the south of England. Many become discoloured by the soil in which they live, but their albinistic tendency is revealed in their pale nose and claws. Their eyes are pink, too, and the black facial stripes are invisible.

Melanic–very dark or all-black–individuals occur in many species as a result of excessive production of black melanin pigment in the skin. Water voles in the north and west of Scotland, for example, such as this one, are mostly black; elsewhere in the British Isles they are orange-brown. Melanic wood mice and grey squirrels also occur. Black rabbits are quite common, particularly in geographically isolated populations such as those living on islands like Skokholm and the Farnes. Melanic snakes occur too, but should not be confused with normal coloured specimens that tend to go dark just before sloughing their skin.

Right: An albino fallow deer buck. Very occasionally whiteness may actually save an animal from destruction by man. White fallow deer, for example, are often seen in deer parks, retained because of their interest and striking appearance.



MUD-LOVING GREY MULLETS

Grey mullets are common fish of our southern coasts. They have an unusual feeding method, swallowing mud to digest the plant and animal life it holds.

Above: By August, young grey mullets, some 3-4cm (1-1½in) in length, can be seen in rock pools and close inshore on our coasts, swimming in closely packed, fast-moving schools. They grow for 8-10 years, making offshore migrations in winter to avoid the cold, before they return south to their spawning grounds.

Grey mullets are streamlined fishes with broad heads, solid-looking bodies and forked tails. They have large, tough scales on the body and over most of the head, a single anal fin and two dorsal fins. The first dorsal fin contains four slender but strong spines. The mouth is wide and set at the extreme upper surface of the head, and the lips are hard, fringed with fine external teeth. In colouring, all species are dull green or blue-grey above, with silvery sides. There are six or seven grey stripes running lengthways along the body, and the undersides are dead white.

Distinguishing grey mullets The most common and widespread of the three British species is the thick-lipped grey mullet (*Chelon labrosus*). It is the largest British species, growing up to a length of 75cm (30in) and a weight of nearly 4.5kg (10lb). The lips are broad and thick, and they are covered with coarse, blister-like features called papillae along the forward edge. There are also close-packed, small teeth.

Neither of our other two species is so abundant or so large as the thick-lipped grey mullet, and neither has the distinctive broad lips. The golden grey mullet (*Liza aurata*) has narrow lips with moderately large teeth on the edge of the upper lip. Its colouring is the same as that of other grey mullets, but it has a conspicuous golden spot on the cheek and gill cover, which gives it its species name. Also, its pectoral fins are moderately long and, if folded forwards, reach as far as the pupil of the eye.

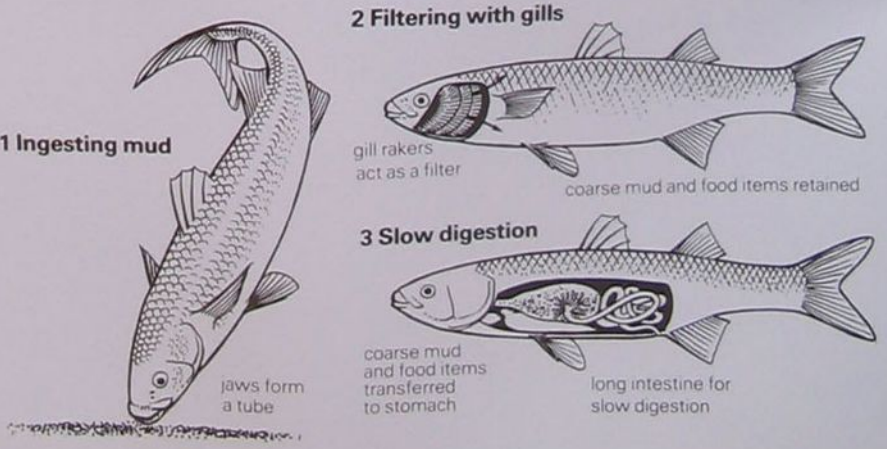
The third species is the thin-lipped grey mullet (*Liza ramada*); it has a narrow upper lip, but with tiny, bristle-like teeth on its edge. It lacks the conspicuous golden patch on the side of the head, but it may have a gold tint–which often leads to confusion. However, it always has a distinct dusky spot at the base of each pectoral fin, and this proves to be one of the most useful diagnostic features. The shortness of the pectoral fin also helps in identification, for if the fin is folded forwards, the tip does not even reach the near edge of the eye.

Where they are found However, if appearances are confusing, the habitats of the fishes sometimes offer clues to their identity. The thick-lipped grey mullet occurs all round the British coast, usually preferring shallow inshore waters along sandy or muddy shores, in harbour mouths and the extreme outer part of the estuaries. The thin-lipped mullet is less widely distributed, and is rare off the northern coast of England and off Scotland. It also occurs in shallow inshore waters, but also shows a strong liking for fresh water. If a grey mullet is caught far up-river in fresh water, then it is virtually bound to be a thin-lipped grey mullet. The golden grey mullet is the least common of the three species, and is found only on our south and south-western coasts.

Watching grey mullets Because they live in

Below: The chief feeding method of grey mullets.

How grey mullets feed



shallow water, grey mullets can sometimes be seen from the shore. A typical habit is to move over the sea-bed with their heads turned down towards the bottom, in a close school in which all the fish are of about the same size. Equally as often, they can be seen in small groups working their way over the pilings of piers, breakwaters or harbour walls, and sometimes along rock faces under water. This behaviour suggests that they are grazing on the fine green algae that cover such surfaces in shallow water. On the sea-bed, they feed in a different way, protruding their jaws to form a tube through which they suck up the surface layer of the mud or sand.

A gutful of mud Examination of the gut contents of grey mullets suggests that they feed very largely on mud, and in a sense this is true. The surface mud of inshore waters is a rich environment in which many minute worms, algae and other organisms live.

However, feeding indiscriminately on such minute organisms poses problems, as they are mixed up with the mud and soil that the mullet sucks in. The finer particles of mud can pass through the fine mesh of the fish's gill rakers and are puffed out with the water through the gill openings. Coarser mud, and the small animals and plants, are retained on the gill rakers and mixed with mucus, and are eventually swallowed.

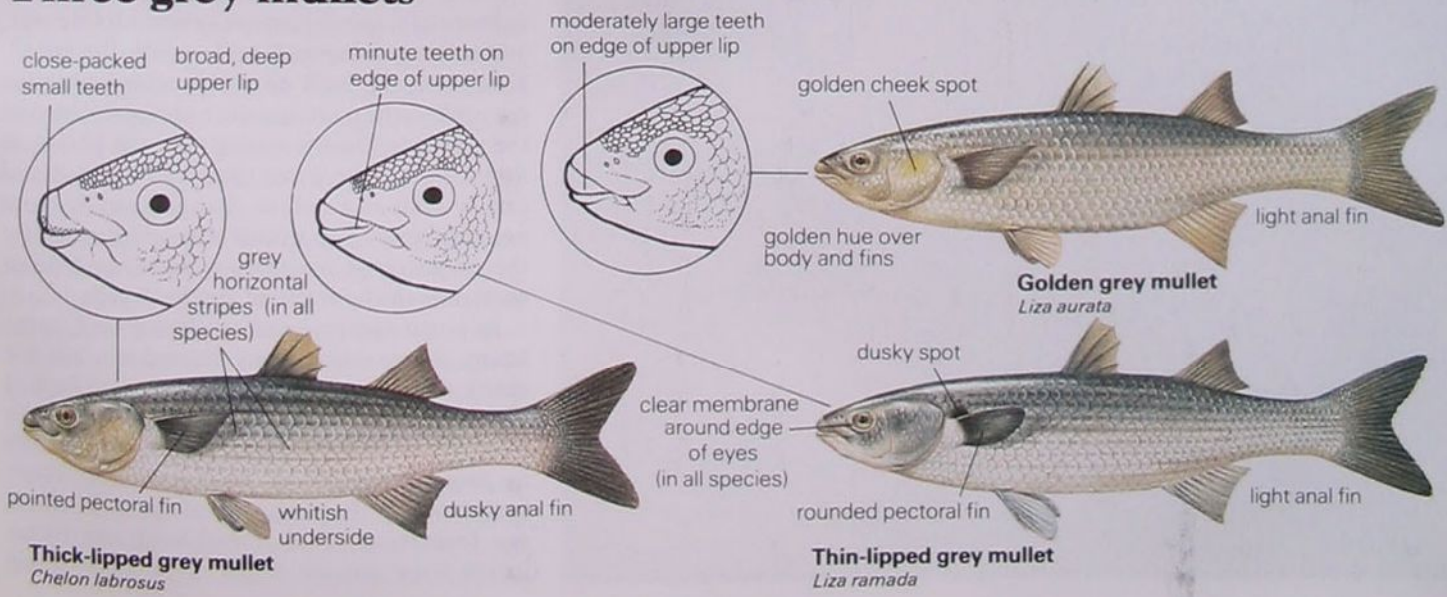
The stomach of a grey mullet has a thick, muscular wall to grind the soil and food to a smooth consistency, making digestion more efficient. The mud-eating habit provides the explanation for the very long gut. On average, there is less than 15% organic matter in the food a mullet eats, so the fish has to take in a large volume of material and be able to retain it for long enough to digest the small amount of nutritive matter it contains.

Summer visitors At the onset of winter, grey mullets seem to disappear from our coasts. Young fishes swim out to sea to avoid the cooling of inshore waters, while mature ones migrate to their spawning grounds.

Right: Very young fry of grey mullet. These are planktonic creatures that drift with sea currents. Grey mullets spawn in late spring. One spawning area has been identified off the Isles of Scilly, and others may be in the Channel area; but most British grey mullets probably originate far to the south.

Below: An adult thick-lipped grey mullet. While the thickness of the upper lip may seem a clear enough identification feature on paper, this feature varies confusingly with the size of the specimen. As a result, it is often extremely difficult to identify small grey mullets. This picture also shows the unremarkable colour scheme of these fishes. The worldwide variety and abundance of the fishes suggests that it is successful as a form of camouflage.

Three grey mullets

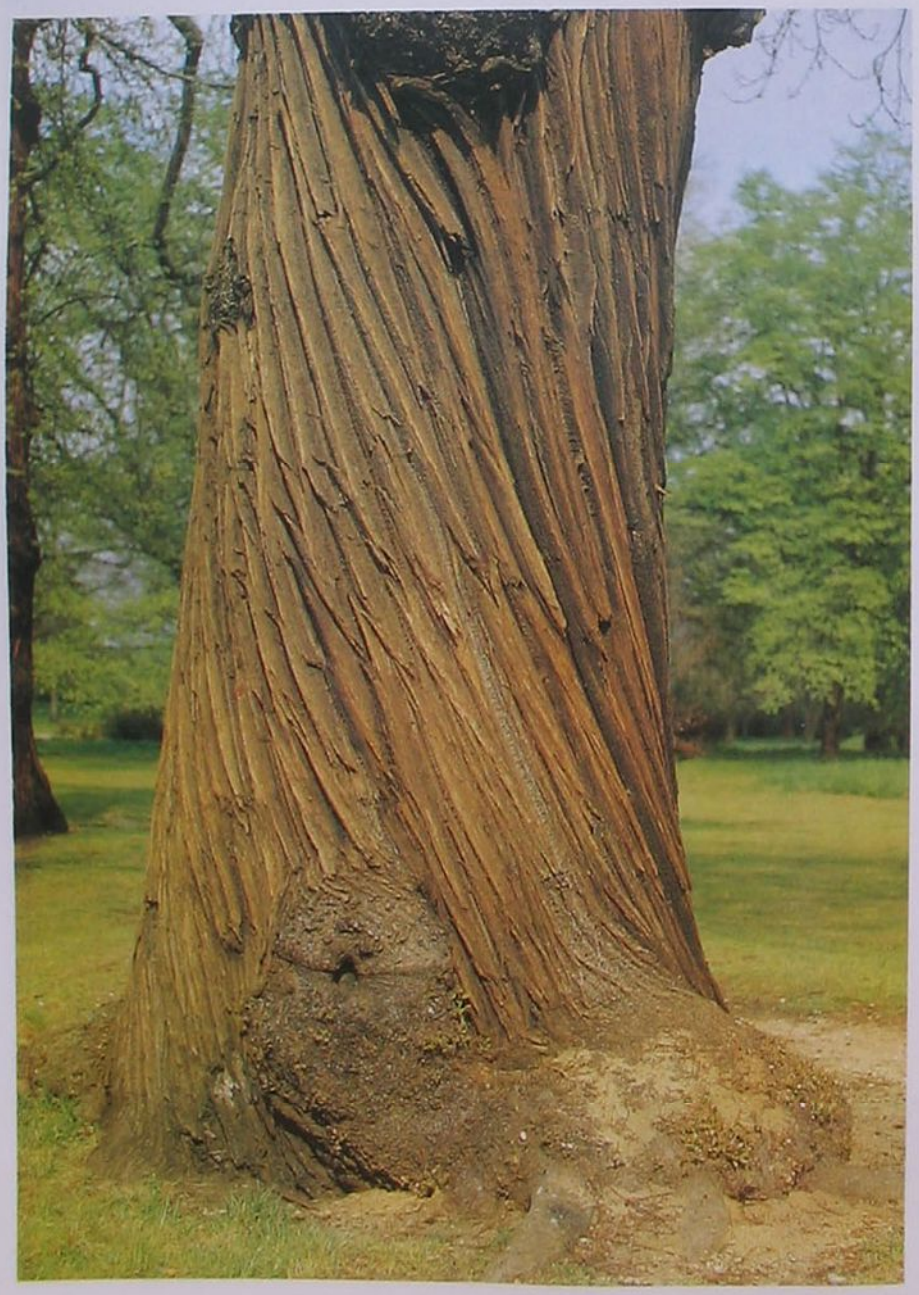


TREE BARK: A PROTECTIVE SKIN

Bark–whether it be rough and fissured as on an oak, or smooth as on a beech–performs the same function in all trees: that of protecting the delicate living tissue in the trunk from the weather and from attack by animals and diseases.

Even the most casual visitor to a public garden will have noticed the immense variation in the barks of trees. The smooth, brilliant white bark of the Himalayan birch and the glossy, reddish-brown, peeling bark of the Tibetan cherry make these two of our most attractive ornamental trees. Among our more familiar species, the sweet chestnut has a strikingly spiralled bark, while that of the Scots pine is a rich brown and falls away from the tree in flakes. To us, the bark of a tree is often a very useful aid to identification, particularly in winter when many trees have lost their leaves. For the tree, however, the bark performs a vital function in protecting it from extremes of weather and against the attacks of a variety of agents, from bacteria and fungi to rabbits and deer.

Below: The rich reddish-brown trunk of the sweet chestnut, combined with the spirally arranged ridges found on many older specimens, make this species one of the few common trees in Britain that can be identified by bark alone.



How bark functions Bark consists of a living inner layer of tissue (the phloem) and an outer dead layer. The phloem plays a vital role in transporting sugars down from the leaves, where they are manufactured by photosynthesis, to the roots and other parts. The outer layer of bark is waterproof and so protects the underlying tissues from drying out. In parts of the world where seasonal fires are a potential hazard some trees have extra-thick barks to insulate the living tissue from the heat. The best known of these is the cork oak from the Mediterranean region, the bark of which has thermal insulating properties rivalling those of glass fibre. Furthermore, the presence of air spaces makes the material light and compressible. Combine this with its waterproof qualities and you have the ideal material for sealing bottles–cork. The cork oak is not often seen in British parks, but its hybrid with the Turkey oak, called Lucombe's oak, appears much more frequently, especially in the West Country.

Bark is also a tree's first line of defence against attacks by bacteria, fungi, insects and larger animals such as deer and rabbits. In most cases it repels these attacks effectively, though large herbivores may destroy so much of a tree's bark in winter when other food sources are scarce that the trunk is completely encircled by the damage. When this happens the tree inevitably dies.

To provide extra protection against this possibility, trees with thin barks higher up often have much thicker barks near the base. This may be seen on both silver birch and Scots pine.

Bark formation Bark is formed by the activity of a special sort of cambium (the wet, green tissue lying just underneath the bark). Known as the bark cambium, this layer plus the corky cells it creates are together known as the periderm. In the young tree, the periderm first arises in the outer tissues of a shoot and can be seen as a colour change, usually from green to grey. The colour change is caused by the presence of waterproof waxes and other materials in the walls of the bark cells.

In some species, such as beech and hornbeam, the periderm thus created can last for many years, slowly increasing in size by cell division as the tree's girth expands. In the majority of trees, however, the first periderm is soon followed by others arising from progressively deeper layers of the stem. With the formation of each periderm, the tissue layers lying outside it are cut off from their

Above: In some species the first layer of bark laid down by the young tree quickly grows to build up a thick layer of corky tissue. On a young Dutch elm (a hybrid between the smooth-leaved elm and the wych elm) this corky tissue splits as the tree grows, forming corky 'wings' around the young shoots. These can be seen on the branches in the picture shown here.

source of water and nutrients, and so die.

Different bark types As the branches and trunks increase in girth resulting from cell division in the cambium, the bark must also increase in size. Thus new layers of bark are continually created within the stem. The number of layers of cork cells produced by the periderm and the depths at which they occur in the stem vary considerably and determine the thickness of the bark. A thin bark, such as that of *Stewartia* species, is smooth while a thick bark, such as that of English oak or black walnut, is rough and fissured.

In some trees the older layers of bark readily peel away or break off. This can be seen in the paper-bark maple and various species of strawberry tree. If the layers remain firmly attached, as in wellingtonia and coast redwood, then a thick bark builds up, which is only gradually worn away. Persistent barks often become deeply fissured because the older, dead, layers on the outside are unable to grow to keep pace with the expanding trunk.

In some species the periderm can completely encircle the stem and, if the outer bark falls away, then whole cylinders of bark can be discarded. Traveller's joy, honeysuckle and paper birch all have such barks. In the case of paper birch, large sheets of its bark were used by certain North American Indians in the building of their canoes.

In other trees the periderm is much more localised, arising one beneath another like overlapping scales. The resulting bark is therefore shed as discrete, irregularly shaped pieces. In Britain, the most familiar examples of this type of bark are those of yew and London plane.

Lenticels for air In common with herbaceous plants, the stem of a young tree contains structures known as stomata through which the stem cells obtain oxygen and lose carbon dioxide. When the stem loses its original epidermis it also loses its stomata and their job is taken over by small lens-shaped pores in the bark called lenticels.

Most woody plants have lenticels on their stems, though they can vary from being microscopically small to 1cm ($\frac{1}{2}$in) or more in diameter. In some species, such as birches, the lenticels enlarge with age.

Other features Along with lenticels, some trees also have spines on their branches or trunks. Hawthorns have spines formed from small branches, though at up to 1.5cm ($\frac{5}{8}$in) long they are insignificant compared with the branched thorns of some honey locusts, which can grow to a length of 10cm (4 in). The more familiar locust tree, or false acacia, has spiny stipules on its younger branches. These were originally at the bases of the leaves.

Occasionally trees produce masses of shoots directly from the bark. These arise from buds that, for most of the time, lie dormant within the trunk. This is a particular feature of the common lime, which often has large tufts of leafy shoots sprouting from its bark. Dormant buds can be very important to the tree as a means of regeneration after a forest fire, damage by lightning or even heavy pruning. The Judas tree is unusual in that it frequently produces bunches of flowers directly from its bark.

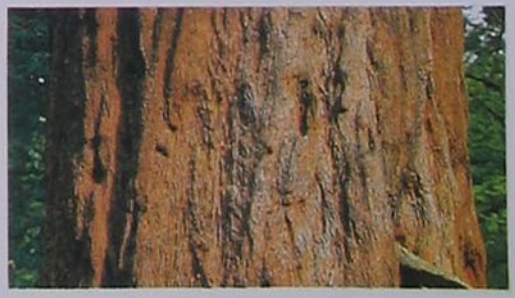
Bark products While some trees are grown for their ornamental barks, other trees have barks that are of considerable commercial importance to us. One of the most familiar bark products is latex, which is secreted by specialised cells arising in the phloem. By making incisions in the bark of certain trees the latex can be extracted and converted into products such as rubber and the gum of chewing gum. Few trees growing in Britain

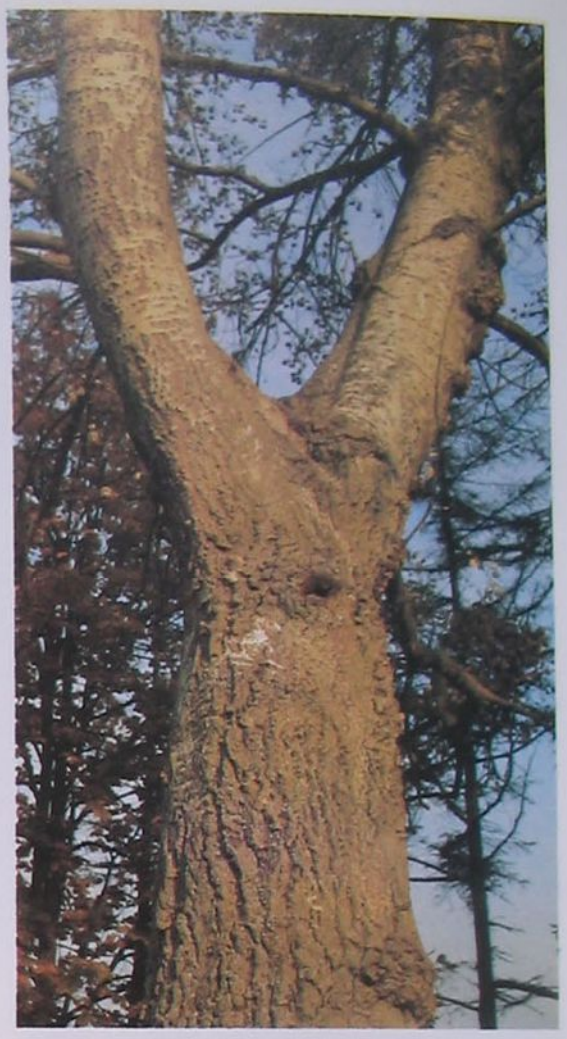
Three bark types

Thick barks, such as that of the black walnut (right), are often rough and deeply fissured into small plates.

The London plane (right) has a thin bark that falls away in plates, reflecting the arrangement of the periderm layers underneath.

Some trees, such as wellingtonia (right), develop a thick, fibrous bark that is only very gradually worn away.





yield latex, but one such is the fig.

Some trees are tapped for the sugary sap carried in their phloem. The sugar maple, for example, yields maple syrup while in southern Europe several species of pine are tapped for their resin. Certain wines are flavoured with resin from the Aleppo pine. Other resin products from pines include rosin and turpentine.

Another very important source of bark products are materials produced by the tree inside the bark cells themselves, mostly as a form of chemical defence against animals and other potential attackers. An example is tannin, high levels of which are found in the barks of oak trees, making them important in the tanning of hides for leather.

Finally, a few barks are used as a source of aromatic products. Perhaps the best known of these is the spice cinnamon, which is the inner bark of a tree from south-east Asia. The scent myrrh is also extracted from the bark of a tree, in this case by tapping the bark and extracting the myrrh from the resin.

Above: The paper-bark maple is now widely planted in parks and gardens for its beautiful reddish-brown bark which peels away in strips.

Above right: The deeply fissured lower part of a white poplar's trunk contrasts with the much smoother bark higher up. Notice the conspicuous rows of lenticels on the upper half of the tree.

Right: Père David's maple, one of a group of snake-bark maples with distinctive silvery-white lines running down their olive-green barks.

Below: A close-up view of the bark of a Scots pine shows it to consist of a series of overlapping scales.

Barks in Britain

NATIVE

Some of the more distinctive barks of our native (naturalised in the case of sycamore) trees.

1 Silver birch (*Betula pendula*).
2 Common beech (*Fagus sylvatica*).
3 Strawberry tree (*Arbutus unedo*).
4 English oak (*Quercus robur*).
5 Hornbeam (*Carpinus betulus*).
6 Crack willow (*Salix fragilis*).
7 Yew (*Taxus baccata*).
8 Scots pine (*Pinus sylvestris*).
9 Sycamore (*Acer pseudoplatanus*).
10 Common ash (*Fraxinus excelsior*).
11 Rowan (*Sorbus aucuparia*).

INTRODUCED

Many of the most attractive barks seen in Britain are on trees introduced here from abroad, in some cases being brought over particularly for the ornamental qualities of their barks.

12 Silver lime (*Tilia tomentosa*).
13 White-barked Himalayan birch (*Betula jacquemontii*).
14 Tasmanian blue gum (*Eucalyptus globus*).
15 Chusan palm (*Trachycarpus fortunei*).
16 Tibetan cherry (*Prunus serrula*).
17 Monkey puzzle (*Araucaria araucana*).
18 Chinese stewartia (*Stewartia sinensis*).
19 Caucasian elm (*Zelkova carpinifolia*).
20 Persian ironwood (*Parottia persica*).
21 Tree of heaven (*Ailanthus altissima*).
22 False acacia (*Robinia pseudoacacia*).

Honey locust (*Gleditsia triacanthos*), an introduced tree from the USA, is unique in having thorns up to 10cm (4in) long sprouting from the trunk.

MOSSES AND LIVERWORTS OF BOGS

Peat bogs are more than just monotonous undulating carpets of *Sphagnum* moss. A variety of other mosses and liverworts also thrive there.

Above: The moss *Polytrichum alpestre* growing in Scotland. Rising above the leafy shoots are the pale brown mature spore capsules borne on long slender stalks called setae. The capsule teeth are immobile and attached to a disc-shaped membrane. Spores escape through the gaps between the teeth.

Below: The leafy shoots of *Aulacomnium palustre*. At the bottom of the picture are a few shoots of *Sphagnum*.

Very few plants can survive in the harsh acidic conditions of a *Sphagnum* bog. The shoots of *Sphagnum* extract some of the few mineral nutrients present in the impoverished habitat and raise the acidity of the bog in the process. Such conditions favour plants with low nutrient requirements.

In some bogs, the flow of water through the great sponge-like masses of *Sphagnum* is either slow or imperceptible, the bog being isolated from any supply of flowing water. This is a true bog, in which rain provides the main source of minerals in exceedingly small amounts. In other areas the blankets of *Sphagnum* moss are open-ended, being fed and drained by streams. In such circumstances there is a slow movement of water across the site, allowing mineral nutrients to be introduced. The result is a mire. In both kinds of habitat a range of specialised mosses and liverworts (bryophytes) can be expected to occur.

Tomentose mosses Bog bryophytes are so well adapted to their particular habitat that any unusual rise in the level of basic minerals in their environment would probably kill them, upsetting their finely balanced internal chemistry. Yet, bog bryophytes lack any obvious physical attributes that separate them from other mosses and liverworts. A common feature, however, of many erect, tuft-forming bog mosses is the possession of a dense

compact covering of thread-like outgrowths around their lower stems. The individual threads are known as rhizoids and the whole covering is the tomentum. The tomentum varies in both colour and extent from species to species. It probably functions like a wick, drawing water and nutrients up the leafy shoot. In *Aulacomnium palustre* the tomentum is reddish-brown and often thick, while *Polytrichum alpestre* has a white tomentum which, to the naked eye, resembles a thin coating of damp cotton-wool. A red tomentum is often produced among the bristle-like leaves of *Campylopus paradoxus*.

Spore dispersal Bryophytes propagate themselves by means of spores, which can be dispersed over a great distance. The spores are produced in a capsule borne on the end of a long slender stalk called the seta. When the capsule is ripe the lid falls off and the spores are released through the mouth of the capsule, which in most cases is ringed with teeth. By opening or closing, these teeth are able to regulate the release of the spores, allowing them to leave only during the dry breezy conditions most favourable for their dispersal.

The setae of bog mosses often grow several centimetres long, enabling the mature spores to be released above the humid, still air that lies close to the surface of a bog. In partially immersed mosses, a long seta may be essential to carry the capsule clear of the water. *Drepanocladus exannulatus*, for example, produces setae that grow to a height of 4-7cm (1½-2½in) above the small curved leaves of its creeping branches.

Leafy liverworts Of the two major groups of liverwort–leafy and lobed–the leafy are most commonly found in *Sphagnum* bogs. In leafy liverworts the spore capsule develops from a fertilised female sex organ called the archegonium, enclosed within in a protective sheath of modified leaves called the perianth. When fully developed the capsule is elevated upon a rapidly elongating seta. (In mosses, the seta grows before the capsule develops.) Among the spores inside the drying capsule are long narrow cells called elators with peculiar spiral-shaped thickenings on their walls. As these cells lose water, they writhe about, increasing tension in the wall of the capsule. Eventually the capsule violently splits into four petal-like segments, which flip backwards exposing the spores to the air.

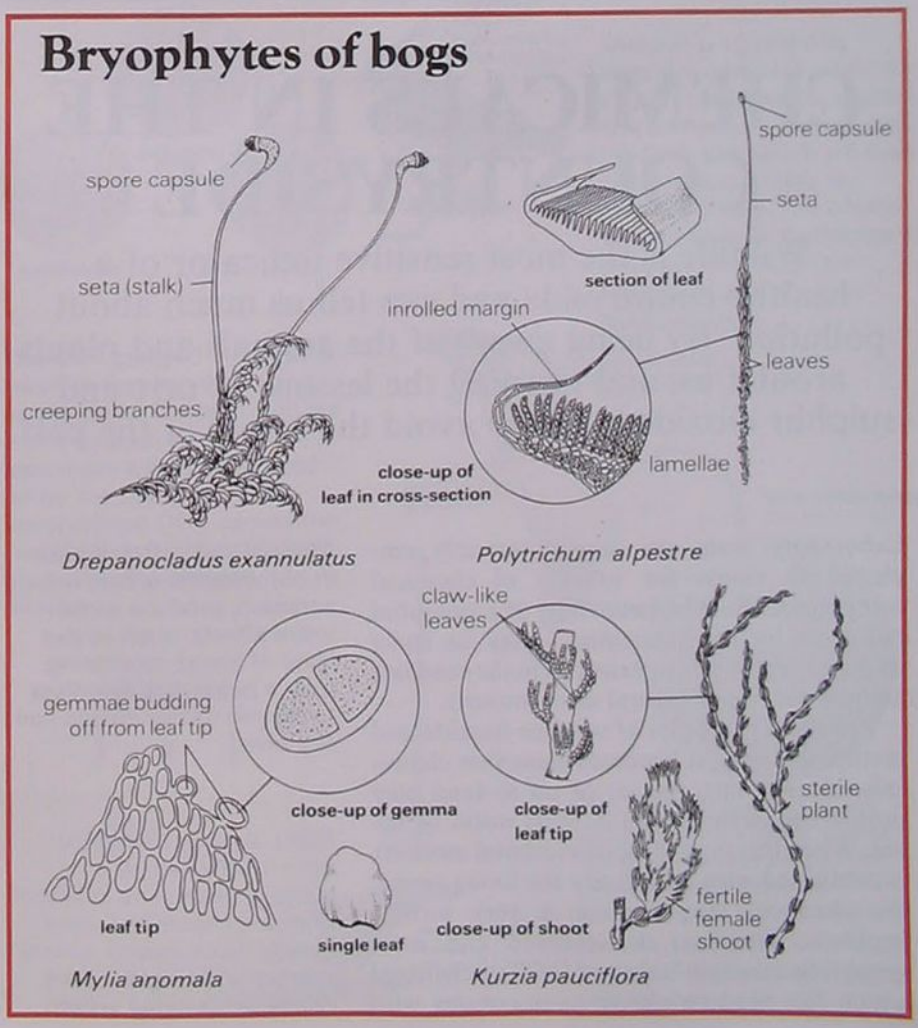
In many bog liverworts the chance of successful cross-fertilisation is reduced by the fact that the male and female sex organs grow on different shoots. Such is the case for *Kurzia pauciflora* and *Odontoschisma sphagni*, which are often found growing together scattered among stems of *Sphagnum*. In both plants, sex organs and therefore spore capsules very rarely occur. *Kurzia* has minute, slender, dark green shoots adorned with claw-like leaves while the shoots of *Odontoschisma* have two rows of round, overlapping leaves.

Above *Pleurozia purpurea*, one of the most conspicuous liverworts of *Sphagnum* bogs. Common only in the moorland bogs of the western Scottish Highlands, its stems resemble a cluster of large rearing caterpillars.

Below: Four bryophytes of *Sphagnum* bogs. Notice how the leaves of *Polytrichum alpestre* have a series of lamellae (parallel longitudinal walls of green cells) partially covered by the inrolled leaf margins.

Mylia anomala, another liverwort with this sexual arrangement, may reproduce asexually by means of microscopically small structures called gemmae, produced along the margins of its leaves. These can become detached and give rise to new plants. Some bog liverworts have organs of both sexes on the same stem, although in spite of this only a few species frequently produce spore capsules. As in *Mylia*, gemmae often contribute to their proliferation.

Many of these bog bryophytes are rare and seldom found outside *Sphagnum* bogs. Yet this unique habitat is slowly being destroyed under the combined effects of pollution and commercial drainage schemes.



CHEMICALS IN THE COUNTRYSIDE

Wildlife is the most sensitive indicator of a healthy countryside and can tell us much about pollution. By being aware of the animals and plants around us, and learning the lessons of DDT and sulphur dioxide, we may avoid the errors of the past.

Laboratory tests are now commonly employed to assess the toxicity of chemical compounds. But the behaviour of a potential pollutant in the laboratory may be quite different from that experienced in the complex and uncontrolled natural environment.

From the examples of sulphur dioxide and methyl mercury, it becomes clear that chemicals released into the air or on to land may poison organisms living in fresh water or the sea. When this type of environmental mobility is combined with an affinity for living tissue, the chemical may become a very serious problem. The best documented and most notorious example is that of DDT, a chemical which has become almost synonymous with pollution.

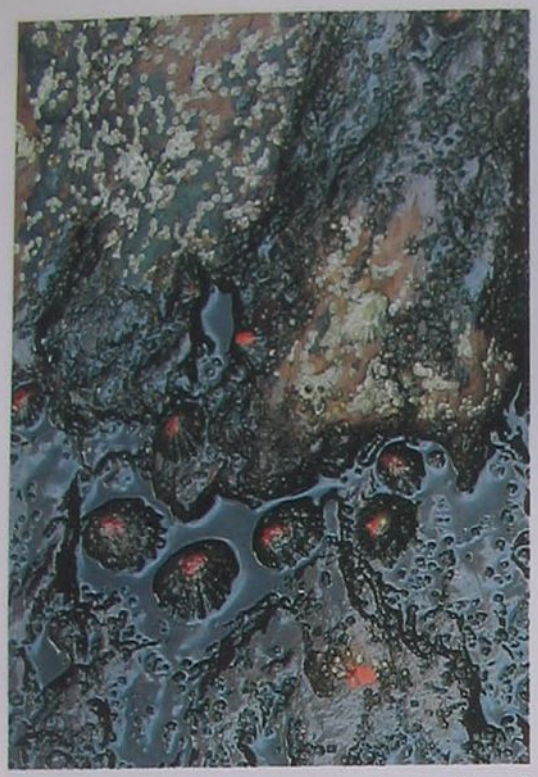
The effects of DDT This chemical was developed as an insecticide during World War II, although it had been known for some time before. It displayed powerful insecticidal properties and was considered a breakthrough in the control of insect pests. It was found to be of low acute toxicity and no more dangerous to humans in high doses than aspirin. However, it was not the chemical's *acute* toxicity which caused problems, but the long-term or *chronic* effects. It is undoubtedly true that DDT had considerable effect on the control of insect pests, including mosquitoes and other insect carriers of tropical diseases, but it gradually became apparent that this wonder chemical was also not without environmental side-effects.

In America, where DDT had been used in high doses to control the beetle-borne elm disease, it was observed that song and game birds in the area became ill and died, even though they were not directly contacted by the spray. It soon emerged that DDT was a chronic pollutant, whose effects were not immediate but built up over a period. Previous tests had concentrated only on its immediate, or acute toxicity.

DDT, together with other organochlorine pesticides, breaks down very slowly and is persistent, remaining active for a long time in the environment. Moreover, it may bind chemically to organic residues and dissolve in the fatty tissues of living organisms. When, for example, an insect or small fish is consumed by a song bird or larger fish, its body-burden of DDT is consumed with it. Thus the levels of DDT in a carnivorous organism high in the food chain will be the total of all the other DDT-affected creatures in its own food chain. Work on an American lake sprayed regularly with a chemical related to DDT showed that

Above: Chemical pollution in our waterways can, on occasion, produce some weird effects–such as this 'river of blood' emanating from a paper mill. Needless to say, no fish or insects can live here.

Right: By way of contrast, this stonefly resting on a blade of grass is an indicator of clean, unpolluted water nearby. Such insects cannot tolerate anything but pure, highly oxygenated water.



Left: Limpets coated with crude oil in a pollution experiment. Laboratory experiments similar to this have revealed that organic mercurials can be concentrated through a process called bio-accumulation. What starts as low and apparently harmless levels of mercury build up to poisonous concentrations in the bodies of living organisms. In Japan, shellfish were found to carry high levels of mercury. Fishermen were posioned when they ate these contaminated shellfish.

whereas the lake water contained a fraction of one part in a million of the chemical and its residues, ospreys and cormorants feeding on fishes from the lake had several thousand times this amount in their tissues.

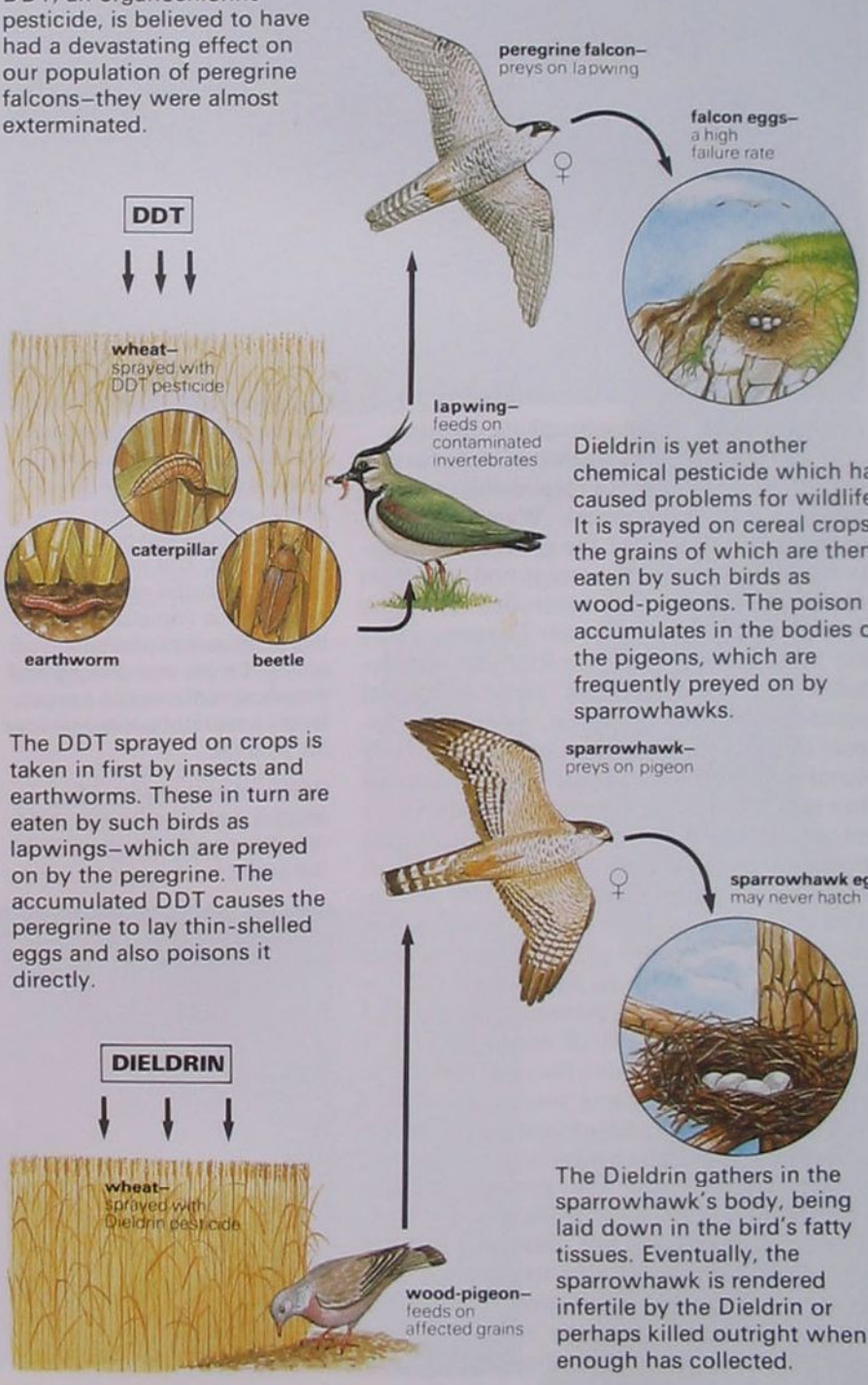
In Britain it is now believed that DDT and other similar persistent organochlorine insecticides were the main cause of the virtual extinction of the peregrine falcon in the 1950s. The bird's hormone balance was affected by the pollutant and the eggs laid were either sterile or thin shelled. DDT is no longer readily available on the domestic market in Britain, and since its control in 1960 the peregrine has slowly recovered to its pre-war population level.

Otter decline Another major casualty of persistent insecticides in Britain was the otter. The decline of this elusive mammal began in the late 1950s, but the reasons for this remained obscure until 1979 when a detailed study was completed by the Joint Otter Group. Paradoxically, it was the otter hunts, previously blamed for the otter's decline, which provided most valuable information in the form of data on otter catches. The otter's demise began at much the same time throughout England and parts of Wales and Scotland. It is thought that the persistent organochlorine pesticides Dieldrin and Aldrin were to blame. They were subsequently banned for spring cereals in 1962 and winter cereals in 1975, but traces of Aldrin are still found in water-courses originating from sheep-dip. Indeed, in 1983 trout from a reservoir in the south-west were contaminated in this manner. With the recent first release of captive-bred otters, conservation bodies will be paying special attention to sheep-dips as sources of serious pollution.

Modern industrialised farming relies heavily on the successful use of insecticides and herbicides. The unexpected deaths of animals and birds in the 1950s and the 1960s was a painful lesson, but one well learned in Britain. The Ministry of Agriculture and the chemicals industry have paid attention to the development of pesticides with specific actions and low residual toxicity. This has also been the case in Europe and America, but elsewhere in the world, in emerging countries where the potential rewards from pesticides in terms of human benefits and profits are huge, standards of health, safety and environmental safeguarding may remain low. Nevertheless, even in Britain, bird deaths still occur–in the winter of 1982 Bewick and whooper swans and brent geese died after eating seed grain

Chemically polluted food chains

DDT, an organochlorine pesticide, is believed to have had a devastating effect on our population of peregrine falcons–they were almost exterminated.



Dieldrin is yet another chemical pesticide which has caused problems for wildlife. It is sprayed on cereal crops, the grains of which are then eaten by such birds as wood-pigeons. The poison accumulates in the bodies of the pigeons, which are frequently preyed on by sparrowhawks.

The DDT sprayed on crops is taken in first by insects and earthworms. These in turn are eaten by such birds as lapwings–which are preyed on by the peregrine. The accumulated DDT causes the peregrine to lay thin-shelled eggs and also poisons it directly.

The Dieldrin gathers in the sparrowhawk's body, being laid down in the bird's fatty tissues. Eventually, the sparrowhawk is rendered infertile by the Dieldrin or perhaps killed outright when enough has collected.

Above: Ribbon of destruction winding its way through the landscape–this is the River Anker, near Nuneaton, at a point where sewage is discharged. The water is heavily polluted and smelly and there is copious foam on the surface that prevents sunlight from penetrating and therefore reduces the oxygen level–with fatal consequences for wildlife.

Below: Another sign of serious water pollution–dead fish, floating belly upwards at the surface.

treated with an organophosphate dressing.

Water pollution The quality of water in our rivers and streams is the responsibility of the regional water authorities. Water purity is important and most of the gross contamination of water courses by sewage and industrial discharges has now been controlled. The most famous example is the Lower Thames, where life has returned to a once foul and disease-laden river as a result of years of careful control measures. However, pollutants appear in many forms. The recent trend in dairy farming has been to change from traditional hay making to silage. The liquor produced by an average size silage clamp has the equivalent potential to pollute fresh water as the total sewerage produced by a town of 50,000 people. The wet spring of 1983 caused water authorities and the Ministry of Agriculture to issue warnings to farmers to take extra care as overflowing pits threatened rivers and streams. The discharge of silage effluent is illegal and carries a heavy fine, but the effects on a river may take many years to fade.

A more insidious and uncontrollable source of fresh water pollution is currently giving rise to growing concern. The problem here is believed to be not toxic pesticides or illegal industrial discharge, but nitrates–chemical compounds which are vital to plant growth. In various formulations nitrates are applied to grass and arable crops to stimulate their growth. The exact concentration and blend of chemicals in a fertiliser depend upon the time of year and type of soil, but nitrates are extremely soluble in water and are rapidly washed out by rainfall. A proportion of the nitrate compound with which crops are dressed eventually reaches streams and rivers. In some areas, notably the Norfolk Broads, fertiliser pollution of water courses has radically affected the species of plants and animals once found there. High nitrate levels favour some species at the expense of others. But this is not, however, the main reason for the concern at rising nitrate levels.

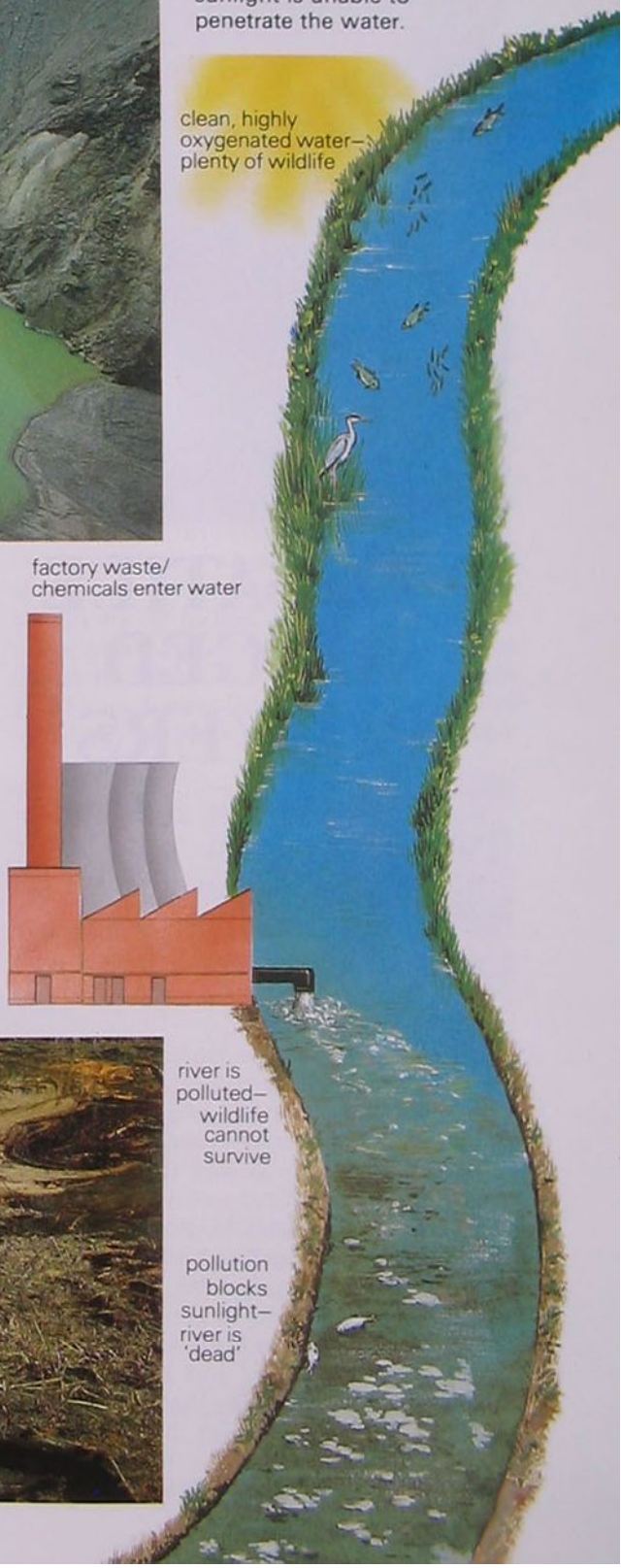
In some water authority areas rivers are important sources of drinking water for the major towns and cities. In the lower reaches of rivers such as the Thames, levels of nitrate have now become high enough to require careful monitoring. Nitrates and nitrites in concentration are particularly toxic to young children. In the future, traditional sources of drinking water may have to be abandoned due to an accumulation of such fertiliser-derived contaminants.

Pollution in the sea The sea is the eventual sink for the majority of pollutants. Discharges into the air, on to the land and into rivers may all accumulate there. In addition to this, large quantities of sewerage, power station cooling water, rubbish, oil and an indeterminate catalogue of other contaminants are poured daily into the earth's oceans. In fact, the extent of marine pollution is unknown and in any case the chemistry of sea water is too complex for chemical interactions and by-products to be predictable.

Perhaps oil is the substance which is most often associated with marine pollution for, despite the amount of money and resources which the oil producers can muster, it remains a serious and intractable problem. The amounts of oil which can be legitimately discharged into Britain's coastal waters is regulated by law but accidents and illegal dumping of oil tank washings still cause considerable problems. In July 1983, a large oil slick of unknown origin threatened the gannet colony of Flamborough Head, and elsewhere the sight of oiled puffins, guillemots, razorbills and seagulls is all too com-

Waterway pollution

Industrial waste products pumped into our waterways are more often than not the villains of the piece when what was once a clean river becomes polluted. There are two main dangers to wildlife here: the actual chemicals kill some of the plants and animals, while others succumb to the lack of oxygen that results when sunlight is unable to penetrate the water.



mon. Even otters have died from oil spills within Sullom Voe in the Shetlands–normally an area relatively free from most of the commoner pollutants.

Oil pollution is devastating and visible; other marine pollutants may be equally serious but take years to manifest themselves. Radio-isotopes may be, by their nature, a source of long-term contamination, but the precautions and monitoring which accompany radio-active waste disposal at sea are not applied universally and much undisclosed and dangerous chemical dumping also occurs. It is right that there is concern over radio-active waste dumping, but its impact on wildlife may be less than that of everyday materials.

Above: It is almost always the workings of man that cause pollution–as here in this desolate landscape where china clay is mined and where no animals or plants can survive.

Below left: Evidence of sea-borne pollution–an oil-covered long-tailed duck washed ashore to die.

Below: Creosote spillage in an ornamental lake in Yorkshire–even such small scale pollution takes its toll of our wildlife.

VERSATILE RINGED PLOVERS

The ringed plover's plumage pattern serves two contrasting purposes: during nesting it is camouflage, and yet in display it is vivid and eye-catching.

Above: A ringed plover at rest on turf. There are two ways you can tell it is not a little ringed plover, even without seeing both birds together: this bird lacks a yellow eye ring, and there is no white border at the back of the black band on the forehead. The ringed plumage is good camouflage, but also has a vivid visual effect when the bird adopts a demonstrative posture: thus it plays a part in the highly developed display behaviour of the species.

Ringed plovers can be found on virtually every beach in Britain, at least for part of the year. They are selective in summer, choosing shingle, shell and sandy beaches, but some disperse in autumn to join flocks of other waders on mudflats and estuaries.

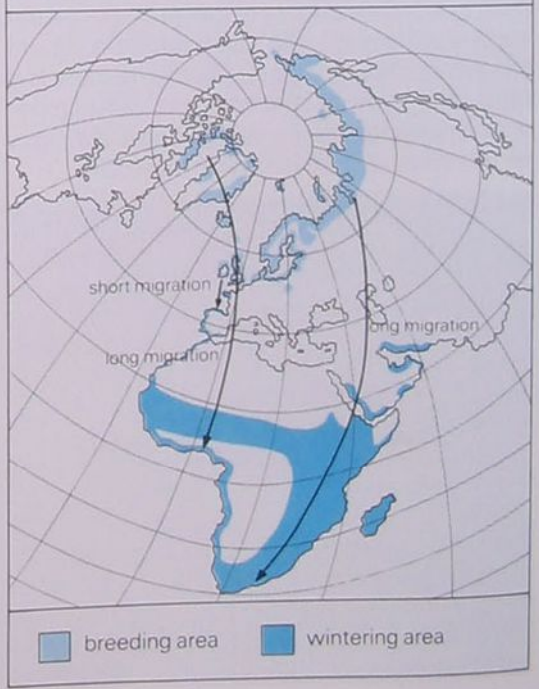
Confusion of identity In Britain, the only bird likely to be confused with the ringed plover is the little ringed plover. Both are aptly named since, especially in summer plumage, they have conspicuous black and white rings or collars on the head and neck. The difference in their size is only slight, so plumage features provide a much better way of distinguishing them.

The head pattern of both species is com-

Ringed plover distribution

Leap-frog migration

From extensive northern breeding areas, most of the world's ringed plovers migrate long-distance to Africa. In doing so, they 'leap-frog' the ringed plovers of Britain and Ireland, some of which migrate 'short-haul' to the Spanish and French coasts, while others winter on the south coast of England, or even nearer their breeding sites.



Identification features

Above left: The ringed plover is a sand and shingle nester, and the form of its nest is typical of all the wading birds: a simple scrape in the ground. The pointed eggs are laid in May, June and July.

Ringed plover
(*Charadrius hiaticula*).
Wader breeding on beaches. Partial migrant, some birds wintering on mudflats and estuaries in the British Isles. Sexes alike. Length 15cm (6in).

Below: The distraction display is performed in order to lead an intruder from the nest. The bird feigns injury and runs or shuffles along with one wing raised and the other dragging over the ground or (as here) folded.

plicated. Each has a pale brown and black cap and a white forehead. Each is also black in front, behind and around the eye, and there is a white collar and chin, and a second black collar below this. However, of the two species, the ringed plover has more black on the crown, and it also lacks the yellow eye ring and a white border at the back of the black forehead band, which are characteristic features of the little ringed plover. The ringed plover's best distinguishing feature is a bold white wing bar, totally absent from its relative.

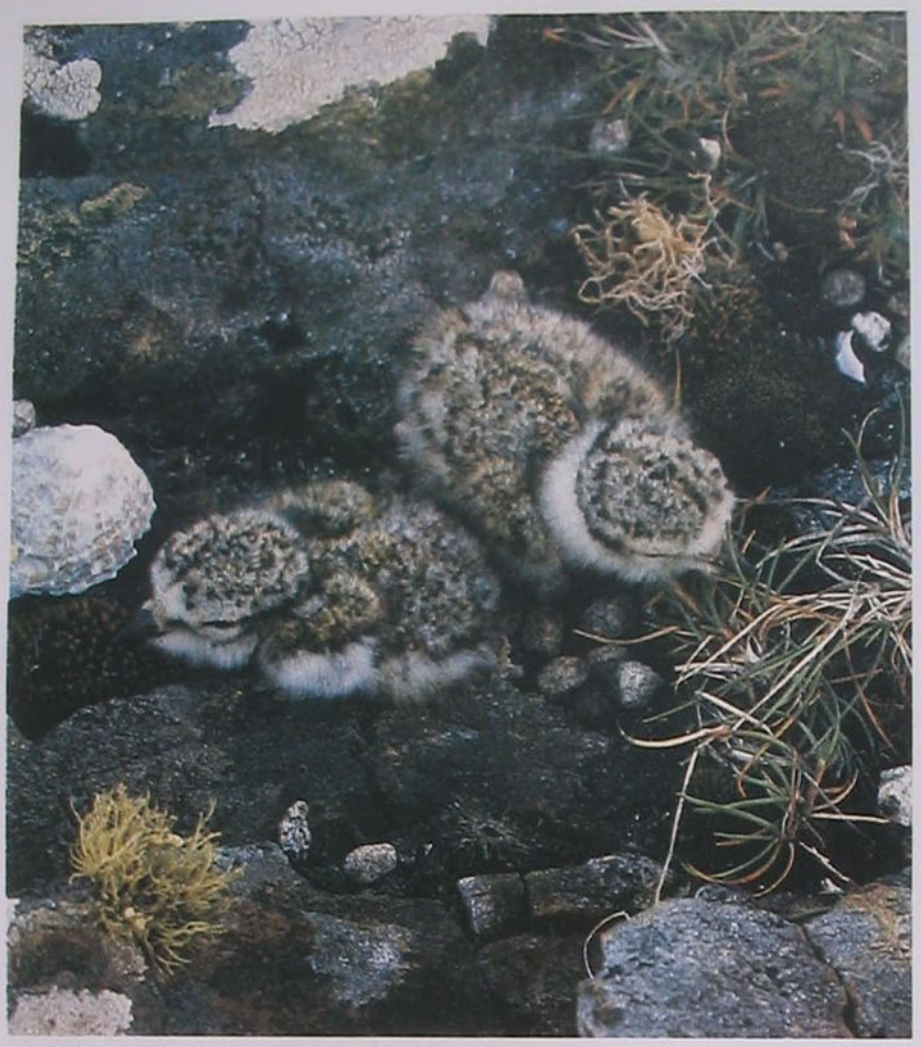
Such striking patterns prompt one to ask what purpose they serve. Recognition of other individuals of the same species is one obvious answer, but a study of the behaviour of these birds shows that two other factors are important: camouflage and display. It might seem surprising that the same plumage should suffice to enable a bird to be either inconspicuous or conspicuous, but this is certainly true of the ringed plover.

Camouflage for nesting Effective camouflage is essential during the breeding season because ringed plovers nest on the ground on wide, open beaches. Shells and pebbles typically give a very varied pattern of stripes and curves in a wide range of colours and shades, and the ringed plover's plumage blends perfectly into such a background. Even sandy beaches usually have a scattering of seaweed and stones which the plover can mimic.

The nest is a shallow depression, lined with small stones and odd bits of vegetation collected nearby. Predictably, the eggs are stone-coloured, being grey to buffish in ground colour, spotted and blotched with black and grey. They are laid one every day or two, four eggs being the usual clutch. The chosen site always has a good all-round view–rocks and other obstacles are avoided–so the incubating bird is able to watch for danger.

On the approach of a predator, or perhaps someone walking along the beach, two alternative strategies are usually possible. If the intruder is unlikely to approach closely, the incubating bird bird may sit tight and rely on its own camouflage for protection. However, if the intruder is likely to come within a few yards of the nest, the better alternative is to leave the nest quietly, run some distance and then fly to safety. The logic behind this course of action is that the nest and eggs are even more difficult to see than the incubating bird, and unless the intruder knows exactly where to look they are almost impossible to find. When the danger is past, incubation can be resumed. Like other waders, ringed plovers have very rapid flight, so it would be possible for them simply to wait and then fly to safety at the very last moment, but this sudden movement would almost certainly reveal the nest site and so jeopardise the eggs.

High failure rate Incubation is shared more or less equally between the two sexes, change-overs occurring at least once each hour throughout the day and night. Off-duty birds usually fly off to feed or stand sentinel on a raised piece of ground nearby, ready to sound the alarm when necessary. Incubation lasts 23-25 days, typical for waders but about twice as long as the average garden bird. Through-



out this time the eggs must be kept warm, even if this means enduring Easter snowstorms in their bleak, windswept habitat.

It has been calculated that 60% of ringed plovers' nests in Britain are unsuccessful, and perhaps as many as 87% of those in eastern England. However, repeat clutches are laid and the majority of pairs probably raise at least one brood; some occasionally manage three. The very first eggs are laid in late March, and the last in July.

Ringed plovers are always careful to position their nests above the high tide mark, but some are still flooded by spring tides. However, the main cause of failure is predation, gulls, crows, foxes, dogs and rats all being to blame. Here, too, we can include ourselves, for many a clutch of eggs has chilled when people have inadvertently stood or sat close to a nest for too long. In cases such as these the camouflage of both birds and eggs is perhaps too effective, for the culprits are usually quite unaware of the problem.

With ever-increasing tourist pressure on our beaches, birds are adapting to alternative sites, so their overall population is probably not declining. Power station and oil refinery compounds have proved ideal, and some birds have nested on farmland by the coast. Further inland, particularly in northern England and Scotland, ringed plovers can be found in a variety of situations near water. Rivers, lakes, gravel pits and reservoirs may all have suitable stony banks.

Above: Ringed plover chicks 'freeze' when they are alerted to danger.

Below: These eggs are beautifully matched in colour with the soil of the ploughed field.

Displays for many occasions Both male and female ringed plovers frequently perform eye-catching mock-injury displays in defence of their young, drawing the predator away from the nest. The birds also defend their nesting and feeding territories from one another, though in this the male is usually more active. Intruding ringed plovers are greeted with a marvellous threat display, in which the feathers on the breast, back, crown and underparts are increasingly erected, greatly accentuating the black and white head patterning. To complete the effect, the tail is fanned, and constant calling draws attention to the display.

Yet more displays are adopted during pair formation, mating and nesting. The easiest one of these to see is the male's song flight. Throughout the breeding season, and particularly during the early stages of the nesting cycle, you can see him circling the territory, flapping his wings with deep, demonstrative strokes and constantly uttering melodious, piping notes.

Animal eaters Ringed plovers feed primarily on terrestrial and coastal invertebrates, using a characteristic 'run-stop-peck-run-stop-peck' technique. Even at night they hunt by sight, watching carefully for their prey to move and then pouncing. Marine polychaete worms, crustaceans and molluscs comprise the main diet, though at inland sites insects, spiders and even sticklebacks have been recorded. On mudflats where food is plentiful, they often group together, but they never form such tight flocks as other waders like dunlin and knot. When the tide covers feeding areas, ringed plovers retreat to roosting sites that they choose for their safety from disturbance: saltmarshes, beaches offshore islets and farmland are all suitable.

A FLOWER FIELD TRIP ON THE DOWNS

What could be nicer than a warm summer Sunday in the countryside looking for flowers–but how do you go about it? To find out, we join botanist Barry Tebbs on a field trip to one of his favourite sites, Chipstead on the North Downs of Surrey.

Barry, who regularly writes flower articles for *The Living Countryside*, had several reasons for picking Chipstead. It is only 12 miles from the centre of London, 'to show you that you don't need to go miles and miles to find rare plants', he explained. 'They are very often on your own doorstep.' Another reason he picked Chipstead is for its variety of habitats. We would be visiting a beechwood, some arable land and finally chalk downland.

We arrived at Chipstead and walked up the side of the valley towards the beechwood. The fringes were a mixture of spindle trees, dogwood, buckthorn, whitebeam and elder, as well as beech trees–all plants typical of the chalky soil we were walking on. The interior of the wood, however, was almost exclusively beech–large, mature trees with heavy canopies. In one place Barry pointed out a couple of trees that had been blown over by the winter gales. 'Trees growing on chalk tend to be shallow-rooted so they are always susceptible to being blown over,' he said.

A farmer's 'dirty' field Carrying on up the slope along the valley, we skirted the beechwood and came to the edge of a cereal field. 'I see the farmer has some ergot in his field,' Barry announced, pointing out a blackened shrivelled head of cereal. 'There's lots of it here.' Apparently ergot is bad news for farmers. It is a highly poisonous fungus that attacks cereal crops and, if it gets into the flour, it can kill. What had happened was that the farmer had been a little late in harvesting last year's crop–wheat–so some of it had seeded itself and sprouted again this year. The ergot had attacked that self-seeded wheat; this year's crop–barley–had not been affected.

The reason why the ergot had attacked only the self-seeded wheat is that modern wheat strains produce offspring plants that are much weaker than the parents. If the weather in spring also happens to be wet then the self-seeded wheat becomes very susceptible to fungal attacks.

On to the downland We walked along the side of the field, then turned off down the valley slope, passing through a narrow band of beechwood. On the other side of the trees the habitat changed entirely. A scattering of

Diversity of downland plants

Shown on the left is a selection of species growing in the grass downland of Chipstead.
Bird's-foot trefoil (*Lotus corniculatus*), whose small yellow flowers are scattered throughout the picture;
Red clover (*Trifolium pratense*) on the left of the picture;
Lesser yellow-rattle (*Rhinanthus minor*), the large upright plant in the middle;
Plantain (*Plantago* sp.), upper middle;
Ox-eye daisy (*Chrysanthemum leucanthemum*) in the background and on the right;
Hawkweed (*Hieracium* sp.), the dandelion-like flower just unfurling on the right.

Above: Even from a short distance away these bee orchids begin to be lost among the vegetation. To appreciate fully the beauty of their flowers you have to move in very close (see left) and use a hand lens.

shrubs and small trees–mainly whitebeams and dogwood–was interspersed with dense patches of grasses and low-growing herbaceous plants. This was the start of the chalk downland.

By the side of the path, Barry noticed some salad burnet, attracted by its distinctive bright red flower heads. He picked some of the leaves and tasted them. 'The books always say that it tastes like cucumber but I don't think it does, though in the past it was used in salads.'

Further along the path, Barry discovered an upright, yellow-flowered plant half-hidden among the tall grasses. 'Here's another example where I don't agree with the books. There are supposed to be two species of yellow-rattle in Britain, greater and lesser, but I have very strong doubts about this. I think they're all one species.'

He bent down for a closer look at the yellow-rattle and took out a hand-lens to show me the structure of the small flowers. 'The books would say that this plant is greater yellow-rattle,' he explained. 'The difference between the two is that greater yellow-rattle should have on the upper lip of its corolla (the petal-tube) teeth which are 2mm or more in length, and twice as long as they are broad. Also, the corolla should bend upwards. Lesser yellow-rattle, however, has teeth less than twice as long as they are broad, and the corolla should be straight. The trouble is that I have found plants with some features of greater yellow-rattle and some features of the lesser one. So I have very strong doubts about whether there really are two species.'

An array of flowers We walked on through the downland and a few minutes later climbed over a stile into a meadow that sloped away steeply to our left. Almost all the shrubs of the previous part of the walk had disappeared, leaving an array of low-growing herbaceous plants.

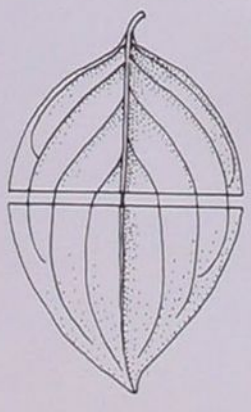
'With the shrubs gone,' Barry was saying, 'all the factors are now right for us to find a very large number of species: lots of light can reach the smaller plants because there are no tall shrubs or trees blocking it out; the soil, being chalky, is well drained, and it is also very warm because it is sloping and so catches the sun. There are even areas where the soil stays fairly broken up, allowing annual plants to survive.'

We walked into the meadow, scanning the ground for plants. Barry pointed some out–rock-rose, bird's-foot trefoil, yellow-wort, wild thyme, wild strawberry, squinancywort and ox-eye daisy. Then we were lucky enough to spot a bee orchid, with its distinctive flowers disguised to look like a bee and attract pollinators.

We sat down to admire this curious-looking plant. 'There's a lot of luck in plant-hunting,' said Barry, 'but professional botanists still have the edge over amateurs when it comes to finding a particular plant because they know the different habitats and what can be expected to grow there. What we do is look for "indicator" plants–plants that tell us we are in a particular habitat. For example the presence of squinancywort in this field tells us that we are sitting on chalk downland because that plant is not found anywhere else. This, in turn, suggests to a botanist that he will find other downland plants in the area, such as certain orchids.'

Furrow for plants Halfway across the meadow, Barry pointed to a furrow running down the hillside. It looked like any other furrow but Barry said that it was a '*Site of Special Scientific Interest*' because two extremely rare plants grow here. Barry began looking and soon found what he was after.

Identifying dogwood



Above: Dogwood is a common shrub of chalk downland. To identify the plant, snap a leaf in half; if you can pull the two halves apart with the veins connecting them still staying intact then the leaf comes from dogwood.

Two very small and inconspicuous plants no more than a few inches high–ground pine and cut-leaved germander.

He explained that a furrow is dug here each year by the Surrey Trust for Nature Conservation to provide these plants with the habitat they both need–newly turned ground. The germander is a biennial and the ground pine an annual so both plants need new furrows each year to seed into. The STNC will soon, no doubt, be digging this year's furrow a yard or two away from the old one so that these plants' seeds will have somewhere suitable to germinate.

'Local naturalists' trusts, by the way, do a lot of useful work like this, and they are also a very good way of finding out about the rare plants in your area. However, if you come across a rare plant, don't tell all your friends about it. If you do, they'll tell their friends and eventually someone will tell the wrong person, who will go and dig it up. It happens all too often. So "keep it in the family"–naturalists' trusts and that sort of folk.'

We sat at the top of the meadow overlooking the furrow running downhill and, beyond it, Chipstead Valley. Barry said that he was expecting to find viper's bugloss–an attractive upright plant with blue and pink flowers–around here; he thought there was some here last year. 'That's another way of finding flowers, by visiting sites regularly and making notes of what you see and where. Then you know where to look next year. I come here every year, and last time there was some viper's bugloss along the hedgerow just ahead. Of course, simply because you see a plant one year does not guarantee that it will be there the next.' However, the viper's bugloss was indeed where Barry thought it would be.

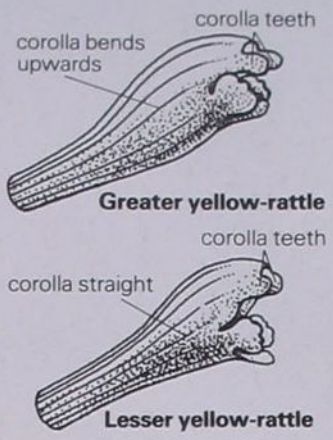
A rare sight We had reached as far along the meadow as we could go and it was time to turn back. We took a different path this time, along the top of the meadow where it met the beechwood higher up the hillside, and it was lucky we did. After a few hundred yards Barry noticed something in the grass to our left. 'More bee orchids,' he said. There were a group of three or four of them about five yards into the grass on our left. Being only about

Right: An early viper's bugloss at Chipstead, and one of the easier plants to identify. Look for the tall bristly stem bearing blue flowers which are pink in bud and when first open, and have bunches of stamens protruding beyond the petals.

15cm (6in) tall, they were not easily seen among the longer grasses, plantains and ox-eye daisies. From the path, indeed, they could hardly be seen, except to an expert eye. We took a closer look and realised that there were numerous bee orchids within a few square yards–a quite extraordinary sight. 'I've never seen anything like it,' said Barry. He began to count them and gave up after 15. 'The strange thing about orchids,' he continued, 'is that you can come back to the same site next year and find just one or two here, or even none. Orchids are the most unpredictable of plants.'

We sat and enjoyed the orchids for a while and then continued back. I asked Barry how the trip had been. 'Excellent,' he replied, 'and from the point of view of orchids, quite amazing.' Apparently we were lucky to have caught so many different plants flowering at the same time. One can never be sure about flowering times. For example, they can all be delayed for perhaps a few weeks by cold or wet weather. Then a spell of warm weather brings them all out at the same time. That's why plant-hunting is such a hit-and-miss affair.

Yellow-rattle



Above: Reference books say that greater yellow-rattle should have more prominent teeth on the upper lip of the corolla than lesser yellow-rattle, and also that the corolla should curve upwards whereas in lesser yellow-rattle it should be straight. On the Chipstead plants, however, a mixture of characters occurs, which casts doubts on the validity of the two species.

Below: Squinancywort, one of a group of plants that are invaluable to a field botanist because they confirm which habitat he is in. Squinancywort indicates chalk downland.

Points to bear in mind

1 Walk slowly when plant-hunting, keep to the paths as much as possible, and scan the ground around you for plants. Try not to step on any small species.

2 Plants are often a lot smaller in reality than they appear to be in books. Many of the smallest plants are also among the rarest and most interesting.

3 Take along a field-guide book with you and identify the plants as you see them. Keep a written record of what you find; a photographic record is also a good idea.

4 Once you have identified a plant, study it closely. Then, the next time you see one, you will be able to identify it much more readily.

BLACK 'CROWS' ON THE FARM

The rook, crow and jackdaw all co-exist on farmland without competing, for each has its own requirements for food, nest sites and living space.

The crow, rook and jackdaw are all outwardly similar members of the crow family–so similar, in fact, that many people refer to them all simply as 'crows'. They are all common species on agricultural land, but they are able to share this habitat because each exploits it in a different way, so that they do not compete with one another for the necessities of life–food, nest sites and living space.

Three black birds Although they are superficially just black birds, these three 'crows' do differ in appearance. The most distinct is the jackdaw, which is the smallest of the three at about 32cm (13in) long. It is mainly black, but its chief distinguishing feature is the colour of the cheeks and nape, which are a silvery grey. At close range you can see that the black feathers of the crown, wings and tail are glossed with blues and greens, and that the eye is a conspicuous bluish silver. In flight, the fast wing beats and the call of the jackdaw are also characteristic. The most usual call is a short, high-pitched 'chack'.

The rook and crow are similar in size, about 45cm (18in) long, and at a distance both appear uniformly dark. The adult rook, however, is glossy bluish black or purplish black all over, while the crow is generally a duller black with little gloss. The bills of both species are much longer than that of the jackdaw, but while that of the crow is black, with bristly feathers around its base, the bill of

Above: Rooks at a rookery near Selborne in Hampshire. Rooks build their nests in the upper branches of tall trees, while crows nest in the fork of a branch.

Below: For people who live in northern Scotland and the northern half of Ireland, separation of the rook and crow is a much simpler matter than in the south. In these places there is a different variant of the crow called the hooded crow or grey crow. Its back, belly and breast are grey.

the adult rook is grey, tending to white at the unfeathered base.

Social or solitary Differences in the appearance of our three lowland crows are rather subtle, but other aspects of their lives show more marked variation–particularly regarding their degree of sociality. Crows are generally solitary creatures, spending their time alone or in pairs, although family parties can of course be seen for a few weeks after the young leave the nest. Rooks and jackdaws, on the other hand, live in flocks which can number from a dozen or so to several hundred, and sometimes over a thousand birds.

For most of the year rooks and jackdaws live in mixed flocks, and often these flocks are joined by other birds such as starlings, lapwings and gulls. However, the country adage 'one rook is a crow; a flock of crows are rooks' is not absolutely true, for occasionally rooks, especially juveniles, do feed alone and crows, especially youngsters, do form flocks.

Differences in sociality tend to be stricter during the breeding season, when pairs of crows invariably defend the territories in which they feed and build their nests. Rooks and jackdaws are generally colonial, and solitary nests are something of a rarity. The rook's nesting colonies are the familiar rookeries which can number from a few nests to over a thousand, but these really large rookeries occur only in Scotland. Both the rook and crow build their nests in trees, using twigs, earth and grasses. They usually select tall trees, but while the crow builds its nest in a fork, the rook chooses the slender upper branches.

Apart from their noisiness, jackdaw colonies are less obvious than rookeries because the nests are built in holes. The most frequently used holes are those in buildings (especially derelict buildings, but also the chimneys of inhabited premises) cliffs and trees, but other sites, such as rabbit burrows, are sometimes used. In large holes, vast quantities of sticks and grasses are used to construct a base for the nest, which is lined with wool and grass; in smaller holes the nest consists of little more than the lining.

Carrion crow (*Corvus corone corone*). Resident bird of farmland and gardens. Plumage is uniformly dull black. Length 45cm (18in).

Hooded crow (*Corvus corone cornix*). Northern subspecies of carrion crow with grey plumage on back and underparts. 47cm (18½in).

Rook (*Corvus frugilegus*). Resident farmland bird with glossy black plumage. Length 45cm (18in).

Jackdaw (*Corvus monedula*). Resident on farmland. Small crow with grey patch on nape and cheeks. 32cm (13in).

Right: Jackdaws nest in holes, usually in colonies.

Below: The crow is a solitary feeder and nester.

Rook, crow and jackdaw: how they share the farm

Taking turns The egg-laying seasons of the three species differ: the rook is one of our earliest nesting birds, laying its eggs in March. The crow lays mainly in mid-April, and the jackdaw between mid-April and the end of May. The eggs, 3-5 laid by the rook, 4-5 by the crow and 4-6 by the jackdaw, are variable in colour but are generally greenish, with blackish or brownish spots and blotches. In all species, only the female incubates, and while she is sitting she is fed by the male. The hen broods the young chicks, and at this stage the entire family is provisioned by the male, but as the chicks grow the female leaves them to take her share in feeding them.

Overlapping food requirements All three species are catholic in their tastes for food, eating both animal and plant items. Most of this is taken from the ground. During the feeding of the young, animal foods–mainly earthworms and insect larvae–predominate in the food brought back to the nest since the chicks need animal protein to sustain their rapid growth. Fresh animal material also has another vital resource–it contains about 90% water and constitutes the only water source available for the chicks.

For adults, and for all birds at other times of the year, food selection is less exacting and the diets of all three species encompass a wide range of foods. Furthermore, the diets of the three crows show considerable overlap.

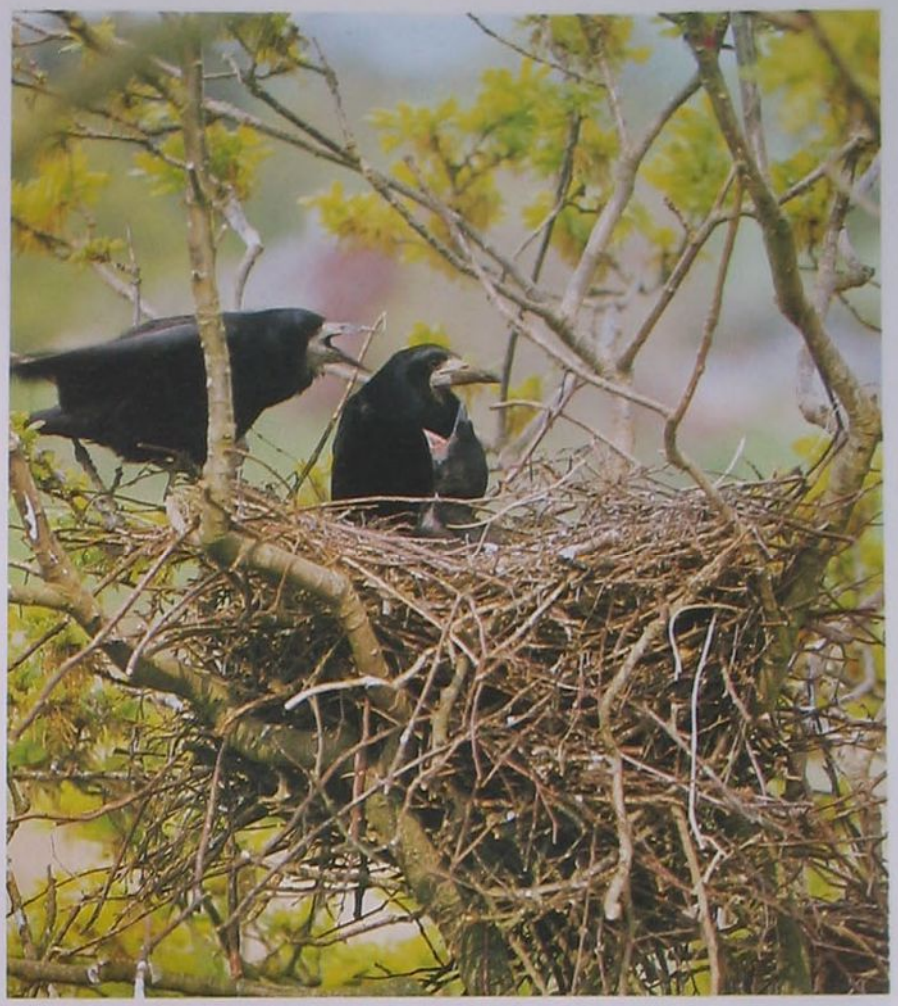
The items the birds eat in common are earthworms, grubs, snails, wild seeds, cultivated cereals, fruit and the wide variety of offal found on rubbish tips. In some parts of Britain, notably in oakwoods, they also take defoliating caterpillars in the early summer–for this purpose they feed in the trees. In general, however, there is a tendency for the jackdaw to take more food items from the soil surface than the rook, which is more adept, with its longer bill, at digging for worms and grubs in the top 7cm (3in) of the soil. The crow takes more carrion, often in the form of birds and mammals killed on the road, than the other two species.

Unfriendly reception There is no doubt that the three crows all take insects that are pests, and that they feed on weed seeds and leftovers from cereal harvests that might otherwise germinate and become weeds. Whether by doing this the birds confer any benefit to the farmer is an open question. At times, however, they all incur the wrath of the farmer or gamekeeper.

In sheep-rearing areas, crows are often blamed for killing or maiming lambs, but good evidence indicates that the vast majority of lambs taken are dead or very close to death, often through starvation, before the crows attack them. Crows are also renowned for their partiality to eggs, especially those of game birds.

Eggs also form a minor part of the diet of some rooks, but this species is of more serious concern for its consumption of several crops: germinating maize; sown, germinating and ripening wheat, barley and oats; potatoes; peas; and the foods laid in the open for cattle, sheep and pigs. Feeding in company with rooks, jackdaws also eat cereals and animal fodder.

Plentiful numbers Recent estimates suggest that there may be around half a million pairs of jackdaws and a million pairs each of the crow and rook in the British Isles. The three crows of lowland farming country are very similar in appearance and life-styles, but clearly their differences are sufficient to allow large populations to live side by side, forming an integral part of our country life throughout all four seasons of the year.



Above: Rooks at a rookery with nestling young. The most useful distinguishing feature of the rook is its grey bill. It is also slimmer than the crow, and has loose feathers on the thighs, giving a 'baggy trousers' appearance.

Below: Inside view of a jackdaw nest, after partly removing the boards that form the 'roof'. Clutches vary between 4 and 6 eggs, which are generally greenish with dark spots and blotches.

DIVERSITY OF SIZE IN MAMMALS

The largest wild land mammal in the British Isles, the red deer, is about fifty thousand times heavier than the smallest, the pygmy shrew. Between these two are a great variety of species of all shapes and sizes, each adapted to a particular way of life.

If you look at sizes within the animal kingdom, it is clear that even the smallest mammal in the British Isles–the pygmy shrew –is bigger than most insects.

Large and warm This relatively large size of mammals is possibly due to thermo-regulation: the ability of warm-blooded animals to maintain their constant temperature, regardless of their environment. A small animal has a large surface area in relation to the volume of its body, and a large animal a relatively small surface area in relation to its volume. It follows, therefore, that small animals warm up and cool down more rapidly than large ones because heat can be gained and lost through their larger surface area; so

they need more energy to maintain their body temperatures.

This is reflected in their feeding strategies: how much an animal eats, how frequently and what type of food. The common shrew, which weighs only 8g ($\frac{1}{4}$oz), takes proportionately huge amounts of high energy food such as worms–3.5kg (8lb) annually, equivalent to 350 times its own weight. A weasel, which weighs 100g ($3\frac{1}{2}$oz), needs about 11kg (24lb) of mice, voles and other prey animals–only about 100 times its own weight. A red deer weighing 50kg takes 400-500kg (800-1100lb) of food annually, just ten times its own weight. Both shrews and weasels use high-energy food very efficiently and assimilate 80-90% for their metabolism–respiration, growth and reproduction, for example. The red deer, on the other hand, has a low energy diet of herbage, of which it assimilates only 40-60%.

Left: A red deer stag with hinds. The red deer is our largest wild land mammal, and a stag can easily weigh up to 85kg (187lb) and measure 122cm (48in) at the shoulder. At the other extreme is the tiny pygmy shrew (above) which can weigh as little as 3g ($\frac{1}{8}$oz) and measure just 4cm ($1\frac{1}{2}$in), with a tail of 3cm ($1\frac{1}{4}$in). It needs to eat twice its own weight daily to survive; thus its territory is defended fiercely.

Below: Otters, our largest freshwater mammal. Any animal's size is determined by the food it catches. African big cats, for example, have to be large to tackle their prey, but a small carnivore like the otter does not need to be any bigger because its fish prey is of limited size.

These different strategies are paralleled by different levels of activity. The pygmy shrew remains active in its small territory throughout most of the 24 hours. If it is to survive it must ensure that other individuals do not eat its precious food resources, and so it defends its territory fiercely, and not infrequently to the death. The weasel is also active for a large proportion of the 24 hours, often ranging over considerable distances to find food. The limitation on the quantity of food an individual herbivore, on the other hand, can ingest may simply be the time it takes to digest it. When the vegetation dies back during winter and its nutrient value declines, large herbivores such as red and roe deer may then have to depend on the huge energy reserves they have stored as body fat.

If mammals are large when compared with most cold-blooded animals, most whales are

Above: The two sexes of a species are often of different sizes. In bats, such as this pipistrelle, the females are larger than the males. Sexual dimorphism also occurs among stoats and weasels, but the female stoat and male weasel (below) are of similar size and hunt in the same habitat. The wood mouse (left) is almost identical in size to the yellow-necked mouse but it tends to live in different habitats.

certainly large when compared with land mammals: for example, the smallest British porpoise is one metre long, about the size of our largest carnivore. The largest mammals on earth are the great baleen whales–a blue whale may reach a weight of 120 tonnes, equivalent to the weight of 30 elephants. Locomotion is achieved by the vertical movement of the tail which propels forward the streamlined, torpedo-shaped body. The baleen whales subsist on huge quantities of plankton (particularly the euphausiid, krill) which occur in polar regions in summer. The rest of the year is spent at lower latitudes where mating and breeding occur. Planktonic food in these areas is relatively scarce and insufficient to meet the needs of a large whale, so it has to depend upon the resources it has acquired in the summer and stored as a thick layer of blubber. By the end of the winter, a whale will have lost much weight, and it must return to high latitudes to feed again.

So that whales do not freeze to death they are covered in a thick layer of blubber: once again, the smaller the whale, the greater the proportion of blubber in relation to its size. Whales have other ways of coping with the cold: they migrate to warmer waters to give birth and to build up insulating fat for the following winter. Smaller mammals also store energy as fat. This, in addition to reducing heat loss during periods of inactivity, helps them to survive winter.

Although the need to conserve heat affects mammal size and strategy, there are other constraints on the size of a terrestrial mammal. Above a certain weight it becomes difficult for an individual to move, even though it may be able to support itself. Today the limit is reached by the elephant. Above this weight an aquatic environment is needed to help support the huge bulk.

Size and sex Although there is a great range of size in mammals, even within a particular species the sexes may be of different size. The tendency is for the males to be larger than females: over 100 years ago Charles Darwin suggested that this may have evolved because the larger the male, the more successful it was at competing for mates. The consequence of this would be that large males mate with a greater number of females, so passing on to their offspring the genes for strength, and hence success in competing for food and mates.

This may explain situations where the species are polygynous (the male mating with more than one female) as occurs for example among red deer where a dominant stag controls a harem of hinds and defends them from intruding males. Among mammals, males are often able to 'gain' from several such matings in this way because they are not investing so much in nourishment, care and protection of their offspring. Parental care by the male is usually absent in polygynous

species.

The females of many bat species are often larger than males, even when the latter are polygynous, mating with a number of females. Here it is probably the nature of the maternal care which is a crucial factor: females often carry their nursing young with them, making short flights with their babies clinging on to the fur of their mother's belly. If females were smaller they might not have the same abilities to transport their young in flight. Thus the evolutionary advantages of a particular body size may vary between the sexes. In some cases it will be beneficial for the males to be larger, in others it will be so for the female.

Size and food Whatever the causes of a divergence in size between the sexes, the consequences are that they may exploit different energy resources, feeding upon different sized prey. A male sperm whale, which is twice the size of a female, dives to greater depths and may take much larger deep water squid.

However, whereas we might also expect males to be the same size or larger than females, there are a number of instances where the converse is true. In baleen whales, for example, the female is usually the larger, and to account for this we must look elsewhere for an explanation.

It may be that some females become bigger to be more effective mothers. A large mother may produce a larger baby with a greater chance of survival; she must therefore produce a larger quantity of milk to enable it to grow more rapidly, and she may be better at carrying or defending her young. It has been suggested that a relatively large individual can subsist longer than a smaller one because its fat stores will be larger, lasting longer. This may be the case for some baleen whales where the females use reserves stored in summer for reproducing after their migration to warmer waters. They may also provide relatively more milk, which allows their single young to grow at a rate which is the fastest in the animal kingdom.

In stoats and weasels this sexual size dimorphism has some particularly interesting consequences. A male weasel is about twice as big as a female and within the size range of a female stoat. Thus whereas the male stoat and female weasel are of different size and take different sized prey, the female stoat and male weasel overlap in the size of prey they capture and hence come into potential competition. In areas where they occur together, the weasel tends to be twice as abundant and has small home ranges. It shows no apparent difference in the time of day or the nature of the habitat where it hunts. The stoat is a more general feeder and can move from one prey to another, whereas the weasel tends to concentrate upon one or two species of small rodent, particularly voles. There is also some evidence that stoats catch most voles outside their runways, unlike weasels which enter the hides and can take prey from within.

As we have seen, the closer in size that two related species are, the greater the likelihood of competition between them for the same prey, and so the greater the need for habitat separation. Two such species are the wood mouse and yellow-necked mouse in southern England. In the British Isles, these are similar in size and form, and only the presence of a broad yellow chest spot and the pale underfur of the adult yellow-necked mouse distinguishes it from its close relative. Where the two occur together, the yellow-necked mouse tends to live in woodland with thicker cover than the wood mouse, which is more often found in fields of crops and in scrub.

Above: A humpback whale surfacing briefly. Whales are the largest mammals on earth. They can support their great size because of the buoyancy provided by the water.

Below: Grey seals mating, showing clearly the much larger size of the male. Seal pups put on weight fast– around 1.8kg (4lb) each day– and they are soon able to withstand their cold, wet environment. The adults are protected by a thick layer of fat.

WEEVER FISHES: DANGER ON THE BEACH

Above: A lesser weever fish with its venomous-spined fin lowered. The species is widely distributed around our coasts, though fortunately for us it is only locally common. It appears to be less numerous in Scotland and on the west coast of Ireland. At times or in areas where local knowledge suggests the fish may be a danger, the simple precaution of wearing shoes when paddling or swimming should help prevent stings.

Although the vast majority of fishes throughout the world are harmless to man, there are a sizeable number with deadly stings, poisonous flesh or the ability to give hefty electrical shocks. The weever fishes are among the few species dangerous to man in British waters, for they have painful stings.

The venomous nature of the weever fish is reflected in its common name, which comes from an Anglo-Saxon word meaning a viper. Two species of weever are found in British waters, the greater weever (*Trachinus draco*) which can reach 40cm (16in) in length; and the more commonly reported lesser weever (*Echiichthys vipera*) which only grows to about 15cm (6in) in length. Weevers occur all round our coasts, but only in sandy areas, and their distribution is patchy.

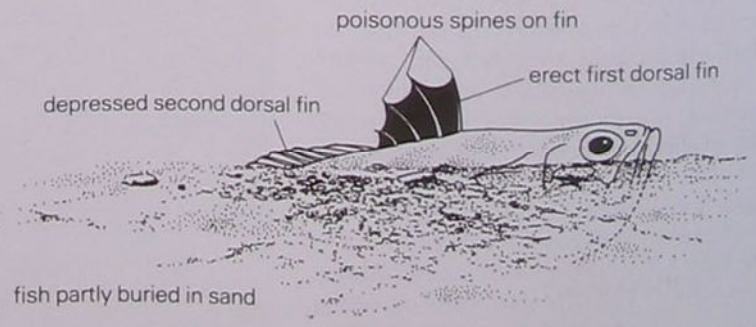
Encounters with the greater weever are less likely because it prefers deep water from about 30 to 100m (15-50 fathoms). The lesser weever lives in relatively shallow water down to about 50m (25 fathoms) and also occurs intertidally. It moves in and out with the tide and occasionally remains on the shore buried in the sand or in pools.

Recognition features Weevers are easily recognised by their deep body and head, with the mouth pointing upwards in a strongly oblique position and the eyes almost on top of the head. On the back near to the head is a distinctive small spiny fin. This is the first of the two dorsal fins, and the spines that protrude from it have venom glands. The gill covers are also armed with smaller venomous spines.

In the lesser weever, this first dorsal fin is entirely black, whereas in the greater weever the fin is only partly pigmented. Weevers are difficult to spot underwater, or even in an

Below: The weever tries to make itself as inconspicuous as possible in order to surprise its prey. It is not an aggressive fish, and normally predators are warned off by the black colouring of the fin

The weever's defence



aquarium, because apart from the camouflage provided by their yellow-brown sandy colour, they spend much of their time partly buried in the sand, often with only the eyes and the treacherous first dorsal fin showing.

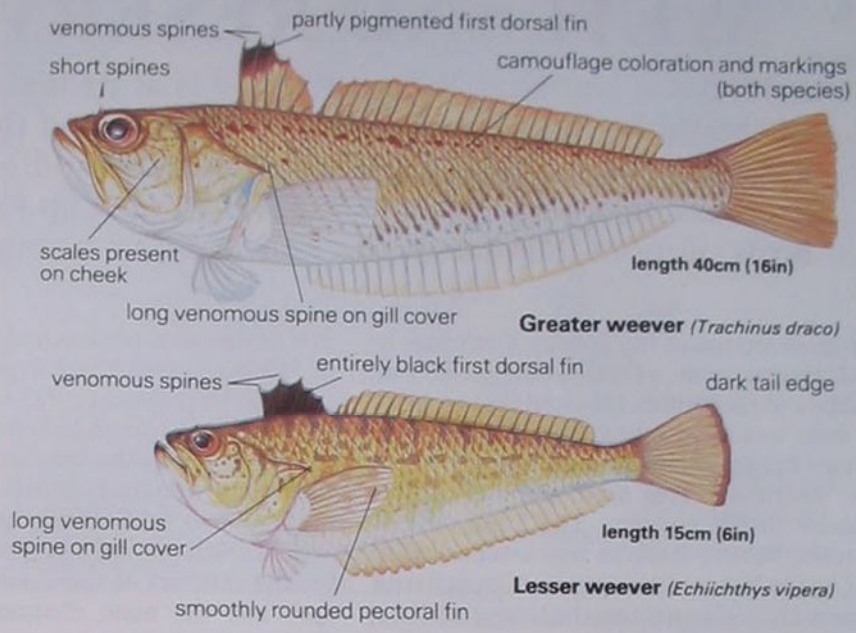
The sting and the remedy It is the habit of lying buried in the sand that makes the lesser weever in particular a danger to bathers and bait diggers on sandy beaches, and to unwary skin divers. The black first dorsal fin is folded back at rest, but at the approach of any intruder–such as a diver or the foot of an unwary paddler–the fin is erected ready to sting. At times a great many of these fishes are caught in shrimp fishermen's nets, since the shrimps also live in shallow sandy areas, and the fishermen may be stung when handling their catch.

Although the sting is intensely painful and may be serious if shock or secondary infections set in, it is not directly fatal. The wound causes local and often considerable swelling of the affected limb and can also result in fainting, palpitations, fever, delirium, vomiting and respiratory distress. Obviously the effects are most likely to be serious if the victim has a weak heart or is a small child. No fatalities have been recorded in this country, though there is obviously a danger of drowning if a bather or diver is incapacitated by the sting.

The pain and other symptoms usually subside within about 12 hours, which gives credence to the old belief among fishermen that the effects would last until the tide returned to the same height as it stood when the injury occurred!

The most widely recommended remedy for weever stings is to soak the affected area in very hot water as soon as possible. The heat destroys the toxic quality of the venom. It is as well to know this, since many doctors and even hospital casualty wards do not even realise that there is such a thing as a venomous fish in Britain, and are not familiar with this remedy.

Identifying weever fishes



Above: It is worth while learning to recognise the weever fishes, and the symptoms that their stings produce, so that victims can be quickly helped and reassured. The greater weever, being a fish of deeper water, is likely to be a problem only for fishermen. On the Continent it is sold for food after removal of the venomous spines. Apparently it is extremely palatable.

For defence only The function of the venomous sting appears to be entirely defensive and protects the weever from attack by would-be predators. A bee sting is similarly defensive, whereas in contrast a snake uses its venomous bite to capture its prey. When erected, the black colour of the dorsal fin of the weever shows up against the pale sandy background, and may serve as a warning.

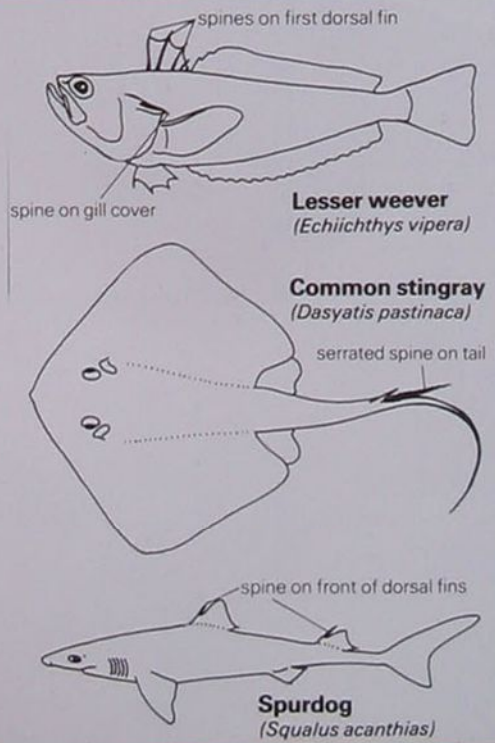
The sole (*Solea solea*) has a black pectoral fin which, if held up when the fish is lying on the bottom, is said to resemble the venomous weever fin. In this way the sole may possibly be a mimic of the weever, frightening off predators; but this has not been proved.

Weevers feed mainly on small bottom-living animals such as amphipods (sand hoppers), brown shrimps, small crabs, sand eels, gobies and worms. They are active mainly at night, but in daylight they can use their camouflaged position in the sand, lying in wait to pounce on passing prey. Lunging movements can bring the fish up underneath the prey, so that the upwardly directed mouth can make short work of the victim.

Spawning and life history Although considerable research work has been done on the venom and stinging apparatus of weever fishes, very little is known about their general biology. Both species spawn in summer between June and August, and some observations suggest that the greater weever may migrate inshore to spawn. The eggs are 1-1.5mm in diameter, and those of the greater weever, though a larger fish, are the smaller.

Venomous fishes

The venom produced by the weever is a complex substance that includes a chemical called 5-hydroxy-triptamine. This is a nerve poison and is one of the most potent pain producing substances known. The venom is produced by the glands at the base of the dorsal fin spines, and when the cells of these glands are ruptured the fluid runs along grooves in the spines and into the victim. The gill covers are also armed with venomous spines. Other venomous-spined fishes occurring in British waters (though deeper than the lesser weever) are the spurdog (which is a small shark) and the stingrays.



CAERLAVEROCK–A WETLAND RESERVE

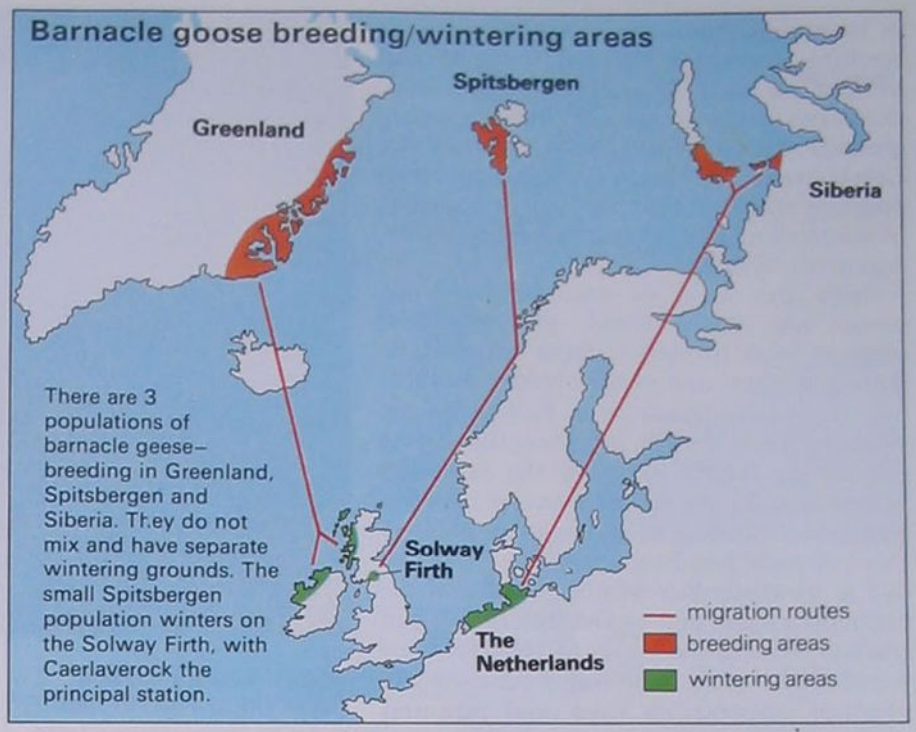
Caerlaverock National Nature Reserve is at its best in winter and should be visited between early October and the end of February for the best of the large flocks of wildfowl and waders. The reserve can be spectacular, with up to 30,000 birds of more than 60 species appearing on a single day.

The inner section of the Solway Firth has the third largest area of inter-tidal sand and mudflats in the British Isles and also some of the most extensive saltmarshes remaining in western Britain. The Solway is also one of the least developed and least polluted major estuaries in the country. The Caerlaverock National Nature Reserve was established in 1957 by the Nature Conservancy Council with the twin aims of protecting the largest and best saltmarsh within this complex and providing a sanctuary for the large numbers of Arctic-breeding wildfowl and waders which winter on the Solway–especially the Spitsbergen population of barnacle geese, whose numbers at that time were very low.

Caerlaverock is the largest wetland reserve in Britain and lies some 11km (7 miles) south-east of the town of Dumfries. It covers a total of 5501 hectares (13,594 acres) of coastal area, of which 600 hectares (1483 acres) is saltmarsh (known locally as merse) and 4901 hectares (12,111 acres) is inter-tidal sand and mud. The reserve is bounded on the north side by farmland but on the other three sides by water –the channel of the River Nith to the west; the smaller channel of the Lochar Water to the east; and the main channel of the Solway Firth to the south.

Many habitats The entire physiographic sequence from bare sand, through pioneer saltmarsh to neutral grassland is contained within the boundaries of the reserve. The huge expanse of foreshore, called Blackshaw Bank, is mainly composed of firm sand and provides both a feeding area for the wading birds and a

Below: At the landward edge of the merse at Caerlaverock is a 32ha (79 acre) marsh called the Flooders (shown here). It lies between an old sea wall and a raised beach and is largely fresh water, being inundated by the sea only when a high spring tide is pushed up by a south-westerly gale. It has a rich and varied flora. In the background you can see Criffel, rising to 569m (1869ft) just across the River Nith to the west and relieving the flatness of the marshes. The merse is owned by the Caerlaverock Estates, who have most generously leased the area as a nature reserve for the past 26 years; the foreshore is similarly leased from the Crown Estate Commissioners.
The eastern end of the reserve is maintained as a sanctuary area for the geese, but visitors to the Wildfowl Trust Refuge at Eastpark can use the hides developed by the Trust and also have access to the NCC watchtower hide, which overlooks the huge expanse of eastern merse.



safe night roost for the large flocks of geese. The merse neatly complements this by providing the feeding area for the geese, which graze its nutrient-rich grasses, and a high tide roost for the waders.

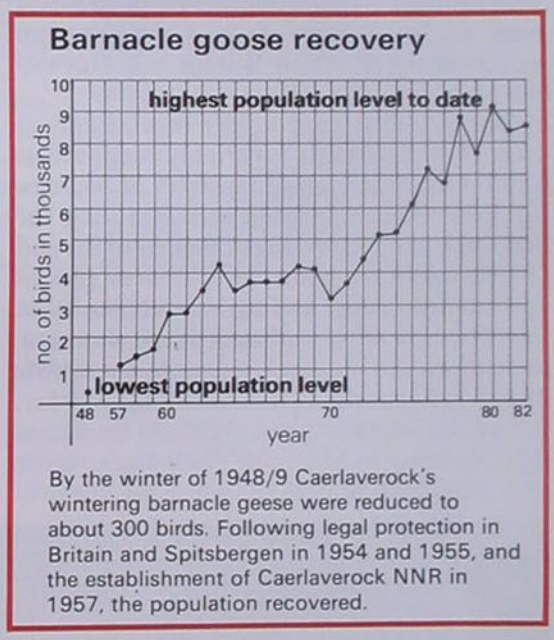
Along the accreting edge of the merse the principal sand-stabilising plant species is *Puccinellia maritima*. The main grass on the higher merse is *Festuca rubra*, but in the wetter areas *Agrostis stolonifera* becomes dominant in association with many sedges and rushes. The merse is inundated by the highest spring tides and is much intersected by creeks and channels, which quickly drain off the salt water. Most of the merse is grazed by the local farmers' cattle from May to September, this summer grazing benefiting the geese in that it encourages a close sward, which in turn gives better winter grazing for them. Another aspect of management on this large reserve is a wildfowling zone, strictly controlled by permit issue and wardening, over 186 hectares (460 acres) of the central merse.

Because of changes in the river channels from time to time, there is a cycle of erosion and accretion at the edges of the merse. For the last three decades the westernmost 5km (3 miles) of the merse edge have been eroding, while the 5km (3 miles) to the east have been accreting at a steady rate. Overall the inner part of the Solway Firth is slowly silting up.

Barnacle goose success story Barnacle geese have wintered at Caerlaverock for at least 200 years and probably far longer than that. At the turn of this century they were described as very abundant and their numbers probably exceeded 10,000, although they were never counted. In the early 1930s Peter Scott estimated about 5000 but by 1948/49, when a survey was undertaken, only 300-400 could be found. The reasons for the decline are not fully understood, but three factors are likely

Above left: The delicate blooms of ragged robin can be seen on the Flooders from May to August or even later.

Below: Barnacle geese bathing at Caerlaverock–this is the species for which the reserve is justly renowned. After breeding on the island of Spitsbergen some 1130km (700 miles) from the North Pole, the barnacle geese accomplish the return to Caerlaverock, where they overwinter, in a single flight of about 2896km (1800 miles). This probably takes them in the region of two days.



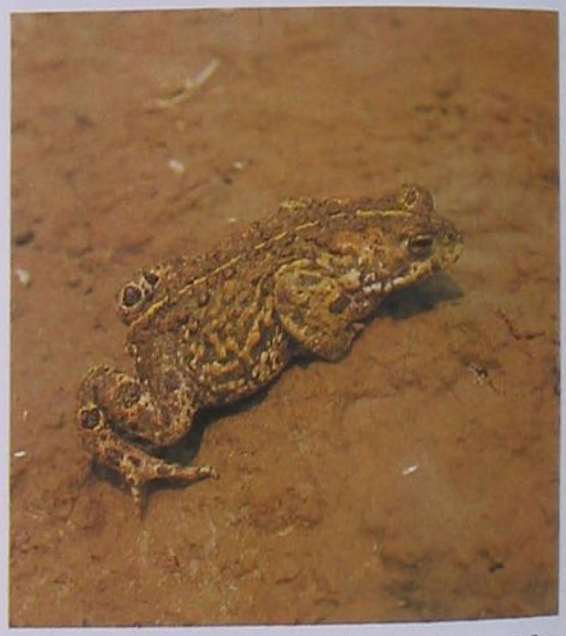
By the winter of 1948/9 Caerlaverock's wintering barnacle geese were reduced to about 300 birds. Following legal protection in Britain and Spitsbergen in 1954 and 1955, and the establishment of Caerlaverock NNR in 1957, the population recovered.

to have contributed to it: a series of poor breeding seasons in the 1930s due to bad weather on their Arctic breeding grounds; excessive disturbance on the wintering grounds during World War II, when the Caerlaverock foreshore was used as a practice bombing range; and the increasing popularity of wildfowling as a sport at a time when the population was low.

From this nadir of near-extinction the corner was slowly turned. Barnacle geese received legal protection from shooting in Britain in 1954, and in Spitsbergen in 1955, and the establishment of a Refuge by the Wildfowl Trust in 1970, adjoining the eastern end of the NNR, increased the protected wintering area, and the geese received protection from shooting in Norway in 1971. A series of good breeding seasons in the 1970s, due to good summer weather, increased the population again and by October 1980 it had reached 9050. In the winter of 1982-83, there were 8500 barnacles wintering. Thus nearly 30 years of conservation work and measures have restored a viable population of barnacle geese to the Solway. It is a conservation success story of which Britain and Norway can be proud.

The barnacles have a very regular annual cycle. The first birds invariably reappear at Caerlaverock in the last few days of September, while the main flock arrives during the first week of October. From then until the end of February they graze the saltmarsh grasses and nearby pasture and barley stubbles. With the cessation of disturbance from shooting, the majority of the flock moves to Rockcliffe Marsh in Cumbria, at the head of the Solway, to feed during March and April. At the end of April or early in May, the whole flock moves to a group of islands off the west coast of Norway, just inside the Arctic Circle. After feeding there for three or four weeks the birds return to their breeding grounds on Spitsbergen.

Above: Greylag geese in flight. Up to 1000 or more roost on the foreshore from November until March.



Right: A bonus for the reserve in the early years was the discovery of a colony of natterjack toads, right at the north-west limit of this attractive amphibian's European range. The colony is at present in a very healthy state, having enjoyed two good breeding years in 1981 and 1982.

Below: Up to 1500 wigeon arrive at Caerlaverock from their breeding grounds in Iceland and Scandinavia.

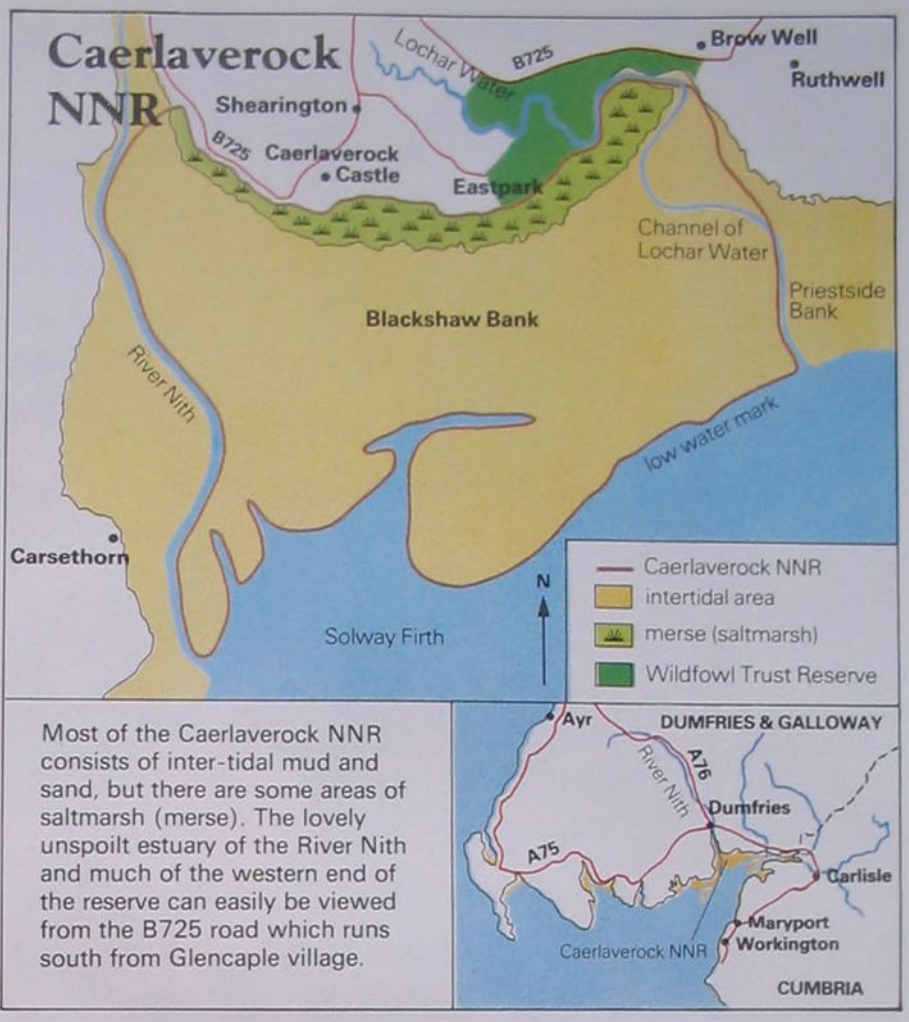
Other geese at Caerlaverock Two species of grey geese, the pink-footed and greylag, also winter on the Solway. The huge sandflats of Blackshaw and Priestside Banks offshore provide one of the best estuarine roosts in Britain for the Icelandic-breeding pink-footed goose. The first birds return by late September and quickly build up to two or three thousand in number. Twenty years ago as many as 10,000 were present in some winters by the end of the year, but nowadays the large numbers come later. Increasingly the pink-feet have taken to remaining in eastern and central Scotland during the early winter, often moving down to the Solway when a hard spell of weather sets in further north. In early February 1983, after a hitherto mild winter, a heavy snowfall over much of Scotland moved large numbers of pink-feet to the south. On 14th February a total of 12,200 pink-feet were counted flighting off the reserve foreshore at

dawn to feed on farmland a few miles inland. This number remained for several weeks, providing a magnificent spectacle as they flighted over the reserve each dawn and dusk in large skeins and V formations.

Fifty years ago greylag geese were more common than pink-feet in winter, but in recent years the larger flocks of greylag have moved inland and further west into Galloway, where they roost on freshwater lochs. However, up to 1000 or more still roost on the foreshore from November until March. White-fronted, brent, bean, Canada and even snow geese are all seen occasionally on the reserve, usually mixed in with the barnacle or pink-feet flocks. Whooper swans from Iceland arrive in October and stay until March.

Yet more birds While almost every species of duck on the British list has been recorded at Caerlaverlock, four species are numerous in winter. Most of the mallard are likely to be of British stock, but the big flocks of teal (up to 1000) which build up each autumn appear to come mainly from eastern Europe. If there is a plentiful spillage on the local barley stubbles, as many as 2500 pintail may stay in the area during October and November, roosting on the reserve foreshore by day and flighting to the fields at dusk.

Each autumn there is a big build-up of waders as the birds return from their breeding quarters on the hills and coasts of Scotland, Iceland, Scandinavia, Greenland and Siberia. Some, such as the greenshank, pass on south after a few weeks, but the generally mild climate of south-west Scotland induces many to stay through till the spring. As many as 15,000 oystercatchers have been counted at the high tide roosts, while curlew, lapwing, golden plover and dunlin are all present in thousands at times. Black-tailed godwits are frequently seen and a spring passage of one to two hundred Icelandic birds is noted annually.



Below: A few Bewick's swans arrive at Caerlaverock from Siberia in November and disappear at the end of February. The 60 or 70 to have come in the past few years are Scotland's only regular wintering flock.

The large numbers of waders and wildfowl attract a following of predators–peregrine, merlin, sparrowhawk and hen harrier hunt over the merse daily in winter. Peregrines have even been seen to tackle barnacle geese on a number of occasions, although their more usual prey is a teal or a golden plover. Kestrels and short-eared and barn owls quarter the marshes for mice, voles or smaller birds, the kestrels hunting by day and the owls flitting silently about by night.

Caerlaverock's flora The flora of the reserve is of considerable interest in its own right and about 250 species of higher plants, representing over 60 families, have been recorded. The plants growing on the merse are all tolerant of occasional inundation by salt water. Grasses, sedges and rushes are well represented, and of particular interest on the merse is the chestnut sedge *Blysmus rufus*, a local northern species. Sea milkwort, sea aster and thrift are typical flowering plants of the merse.

The 32 hectares (79 acres) of the brackish marsh known as the Flooders has a rich vegetation, with the water parts dominated by large areas of horsetail. Here in June thousands of spikes of northern marsh orchid flower, and other common plants include yellow iris, ragged robin, yellow rattle and various watermints.

SAWFLIES: GARDEN AND FOREST PESTS

Sawflies belong to the order Hymenoptera, but can be distinguished from the other members of this group–bees and wasps–by the absence of a waist. The females possess toothed, saw-like ovipositors with which they cut slits in plants for their eggs.

There are nearly 500 British species of sawflies, arranged in 11 families, of which the Tenthredinidae is by far the largest. Most sawflies are rather dull in colour, but there are many black and yellow species–some which mimic wasps–and also a few brilliant species, such as the shiny green *Abia sericea*.

Some adult sawflies, including the stout-bodied hawthorn sawfly, fly strongly in the sunshine, but the majority are rather sluggish and, if disturbed on vegetation, are more likely to scuttle round to the other side of a leaf than take to the air. They all enjoy sunbathing and you are most likely to find them basking on flowers or leaves with their wings folded neatly over their backs. The flower heads of hog-weed and other umbellifers are favourite resting places–and also important feeding sites. Pollen and nectar are the principal foods of adult sawflies, although some are also partly carnivorous.

Vegetarian youngsters The larval stages of sawflies are entirely vegetarian and, although the eggs are laid inside the plant tissues, the majority of the larvae feed externally on the leaves.

Many are similar to the caterpillars of butterflies and moths, but sawfly larvae have at least six pairs of false legs while the Lepidoptera never have more than five pairs. The larvae often live communally, and several species inhabit silken shelters.

Garden sawflies Most gardeners are familiar with the greyish-green, black spotted larvae of the gooseberry sawfly. Working their way around the edges of leaves, these grubs can quickly defoliate a branch or even a whole bush. The adults of the gooseberry sawfly are shy and seldom seen. The female is about 7mm ($\frac{1}{4}$in) long and largely yellow, while the male is black and a good deal smaller.

Another garden pest sawfly is *Arge ochropus*, which spends its early life on roses. One of many sawflies with a black and yellow abdomen, the larvae of this species are yellowish above and bluish-green below, and are decorated with black spots and short black bristles. They feed gregariously on both wild and cultivated roses, starting on the outside of the leaves and quickly eating their way to the centre until all that is left is the tough mid-rib.

Larvae antics If you tap one of the infested rose leaves, all the larvae lift their tail ends at once. This behaviour, sometimes also accompanied by rhythmic waving, is designed to frighten birds. Similar behaviour is found in many other sawfly larvae, notably those of *Croesus septentrionalis* which feed on birch and various other trees. Ten or more of these larvae may cling to the edge of a single leaf, and when they raise their abdomens they emit a pungent odour. Combined with their black, orange and green colour, this affords efficient protection against their enemies.

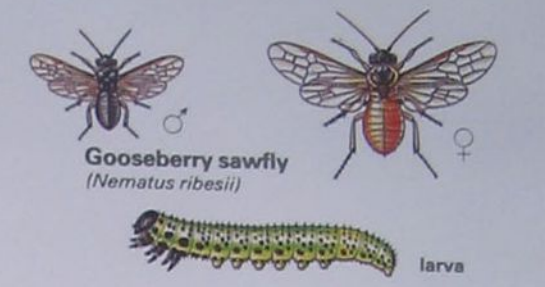
Forest pest Like the gardener, the forester has to contend with an assortment of sawfly

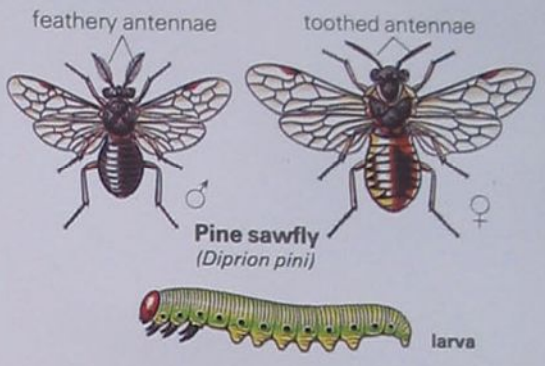
Above: The adult hawthorn sawfly (*Trichiosoma tibiale*) is large and furry and has noticeably clubbed antennae. It is seen on the wing in May and June in the southern half of England. The new adult's emergence (right) is a long and noisy process, sometimes heard from several metres away on a calm day. It uses its large and powerful jaws, rather like a tin opener, to slice through the upper part of the cocoon, which is extremely tough and is found in hawthorn hedges.

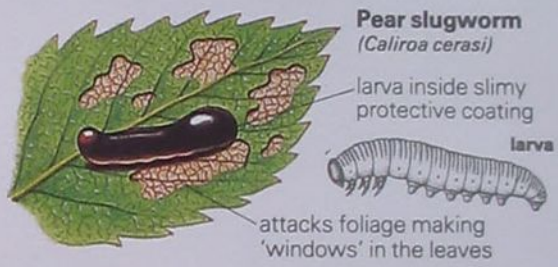
Left: The larva of the birch sawfly (*Cimbex femoratus*), a large species which buzzes noisily in flight. Many sawfly larvae resemble moth and butterfly caterpillars, but if you count the stumpy false legs you will see that sawfly larvae have at least six pairs whereas moth and butterfly caterpillars never have more than five pairs.

Right: Adults and larvae of a gooseberry sawfly, a pine sawfly and a pear slugworm.

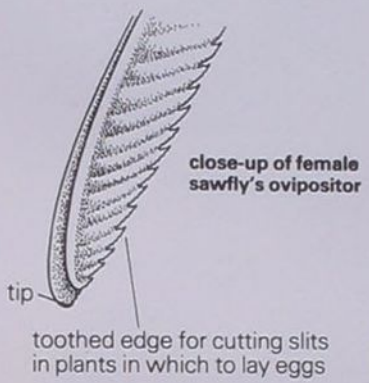
Sawflies and their larvae







The ovipositor



Above: The female sawfly's toothed ovipositor is used to cut slits in plants, into which she lays her eggs.

pests, of which the pine sawfly is the most damaging. The adult male is black with feathery antennae, while the somewhat stouter female is black and yellow with toothed antennae. Pine sawfly larvae are pale green with black spots and feed in masses on the needles and young shoots of pine, causing serious stunting and deformities of the branches.

Sawfly 'slugs' Although most sawfly larvae are caterpillar-like and quite obviously insects, a number of species have greatly reduced legs and are commonly known as slugworms. It is not difficult to see why these larvae are commonly mistaken for slugs for, as well as lacking obvious legs, they have no apparent segmentation of the body.

Among the commonest of these slugworms is the shiny 'pear slug' which is the larva of the sawfly, *Caliroa cerasi*. It is abundant on the leaves of pear and cherry trees throughout the summer, and also attacks other rosaceous trees and shrubs. Instead of demolishing the leaves completely, however, it simply scrapes away the surface layers leaving one or other of the cuticles intact. The presence of the insect can thus be detected by looking up at the branches and searching for pale 'windows' in the leaves. A slimy coating, not unlike that of the true slugs, protects the slugworm from birds. The adults are black, usually with pale markings on the legs, and can be found from May to September.

Pale windows in the leaves of wild or cultured roses are the work of another slugworm, *Endelomyia aethiops*. This is a very pale grub, with rather more obvious legs than the pear slug, feeding on either the upper or lower surfaces of leaves. The adults are small and black, with rather dark wings, and can be

Left: Sawfly larvae feeding on a leaf. If you tap a leaf infested with these larvae they will grip the leaf with their forelegs and lift their tail ends into the air in unison– an action clearly designed to frighten birds.

Below: The beautiful green and black sawfly *Rhogogaster viridis*.

found in May and June. As in many other sawfly species, the males are extremely rare and the females reproduce largely by parthenogenesis (reproduction without fertilisation by a male).

When the slugworm is fully grown it assumes a more normal caterpillar form and crawls down to the soil, or perhaps into a bark crevice, where it spins a tough cocoon in which to pupate.

Tough cocoons Most sawflies pupate in sturdy cocoons, and few are tougher than those of the hawthorn sawfly. Short, brown and tube-shaped, these cocoons are quite easily found in hawthorn hedges in the winter when the twigs are bare. Each cocoon is firmly glued to a twig, and you would need to apply considerable pressure to dent it with your finger. The emerging adult hawthorn sawfly uses its large, powerful jaws to slice through the upper part of the cocoon before it can escape. This is a long and noisy process which, if you are lucky, you can hear from several metres away on a calm day. Adult hawthorn sawflies are on the wing from June to September.

Apple sawflies Not all sawfly larvae feed externally on the leaves of their foodplants. Many of the smaller species are leaf-miners, and some tunnel in fruit. The apple sawfly (*Hoplocampa testudinea*) is a notorious orchard pest which emerges in May to lay its eggs in young apple flowers. The eggs hatch as the fruit begins to develop and the grubs tunnel into the young apples. There is only one grub in each apple, but it has a good appetite and quickly nibbles out a hollow for itself.

Before long, the apple dies and falls to the ground, and the fully grown grub makes its way into the soil to pupate. The adults are mainly black, with an orange patch at their tail end.

Stem sawflies Larvae of the family Cephidae specialise in tunnelling in stems, and they are virtually legless. Members of this group are known as the stem sawflies. Grasses are their main foodplant and several of the sawflies are serious pests of cereals.

One of the commonest stem sawflies is *Cephus pygmeus*. The adult is a slender black insect with yellow bands on the abdomen, and it flies from May to July. It can often be found in thousands on roadside flowers in cereal growing areas. Mating usually takes place on umbellifers or composites and the females lay their eggs on the lower parts of cereal stems in May and June. The grubs tunnel up through the stems and the grain yield of affected stems is very poor.

When fully grown, the grubs return to the bottom of the stems and pupate there. They are not harmed by harvesting or even by the ploughing up of the stubble. Stubble burning, however, does reduce their population to some extent.

Above: An *Allantus* species of sawfly feeding on a dead fly. Pollen and nectar are the principal food of adult sawflies but some species are partly carnivorous and may lurk on flowers, waiting to catch some unsuspecting insect.

Below: A female sawfly cutting a slit in the stem. The species which saw into tough stems usually have larger teeth on their ovipositors than those which lay eggs in leaves.

Bean galls on willow

The leaves of willows and sallows often bear red or yellow growths, about the size of peas, known as bean galls. They are caused by sawflies of the genus *Pontania*, the most common species being *Pontania proxima* (right). As soon as the female sawfly has laid her eggs in the leaf tissues, the bean gall starts to develop. (Each gall contains only one sawfly larva.) As the larva grows it hollows out the gall and makes a hole through which it can eject its droppings. When fully grown it leaves the gall and pupates in the ground. The adults of *Pontania proxima* are on the wing from May to August.